An exploratory research into the design of a medical product-service setup with 2-way augmented reality for the maritime sector.

Graduation report
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Executive Summary

Captains are responsible for the medical care of their crewmembers. To do this, they receive one week of training every five years during which they study the knowledge and practice the skills and processes to handle medical incidents on board. The week of training is not enough for the captains to handle medical incidents confidently and they are in need of support.

Currently, the support for captains is limited to phone calls and email with a doctor from the Radio Medical Services. MedAssist.online invented 2-way-AR technology, a unique method of merging two realities into one using tablets and a green screen. The merging of two realities creates the possibility to give instructions to the captain using hands as an overlay on the video. The 2-way-AR video function is put at the centre of a service which is designed to match the treatment journey and increase the number of interactions between a doctor and captain. A service which uses live video with the addition of 2-way-AR technology has the potential to become the telemedicine solution that boosts the confidence of the captains and their treatment performance.

Boosting confidence is essential to help the captain be decisive in his actions. However, the real value of 2-way-AR is in supporting the captain perform medical skills like stitching and abdominal searches. This thesis researched the tablet positions and camera positions on both sides of the communication. For the doctor set-ups for different tablet positions were designed and tested to give him optimal control over his hands to give instructions. On the captain side, the camera position and tablet position were explored, built and tested. The set-up is evaluated on the understanding of the doctor of the captain's situation, his ability to interpret and implement the instructions and the flexibility of the set-up for multiple medical scenarios.

From testing various set-ups, it was concluded that an additional camera on the captain side improves the ease of understanding for the doctor and his ability to give instructions. At the same time, the captain can put the tablet in a position where he can easily switch between the patient and tablet to implement the instructions, without the tablet obstructing his work area.

This thesis has focussed on the physical set-ups of the tablet, camera and green screen on the captain and doctor side. The final test showed improvements in the new set-up design over the old, but there is an opportunity to improve the communication between the doctor and captain.

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01 Introduction

1.1 Context

The International Maritime Organization(IMO) is the United Nations responsible agency that specialises in international shipping and is: “ the global standard-setting authority for the safety, security and environmental performance of international shipping.”(IMO, n.d.). They set the regulatory framework and make sure ship operators comply to create a level playing field with high safety standards and minimal environmental impact. One pillar of IMO is safety on board of which a substantial part is medical care. With an estimated 1 647 500 seafarers covering international waters accidents are inevitable(International Chamber of Shipping, n.d.). The ILO(2006) set new standards for the care and protection of the seafarers in The ILO Maritime Labour Convention. The conventions proceedings stipulate that any internationally travelling vessel fore more than three days, carrying more than 100 persons, shall carry a qualified doctor(ILO, 2006). This is hardly ever the case for commercial transport vessels which carry cargo who are more likely to carry 25-30 crew members. For these situations, the ILO(2006) states, there should be at least one seafarer on board who is responsible for the medical care. If this seafarer is not a medical doctor certified training is required. The IMO specifies the medical training in the International Convention on Standards of Training, Certification and Watchkeeping(STCW). In the latest guidelines based on the 2010 Manila amendments, the IMO specifies that officers (captains & first mates) require Medical first aid and Medical Care training once every five years(Sekimizo, 2010).

The captain is responsible for his crew and has the authorisation to provide medical care to his crew. At the same time, the captain is responsible for the schedule, safety and compliance with protocols(Study, n.d.). During the training, the officers learn the protocol to handle any medical scenario, learn to identify symptoms and to communicate with the radio medical services. On top of this, they learn basic medical skills like stitching, setting an IV and taking care of burn wounds to prepare them for these scenarios on board.

The training is a basic medical training and in total the two parts only last one week. The short length of the training means the training can only cover a selection of symptoms and skills and the captains get limited practice with potential scenarios. The limited training with the low repetition, once every five years, makes that the officers can struggle with remembering and applying the training. In line with the ILO(2006), they will have a medicine chest on board and the medical guide to support them. On top of the medical guide, every country has a Radio Medical Service. In the Netherlands, the Koninklijke Nederlandse Redding Maatschappij(KNRM) operates this service, which translates into Royal Dutch Rescue Company(KNRM, n.d.a.). They are responsible for the safety and health of people on the Dutch coast or vessels in Dutch waters(KNRM, n.d.b). The Radio Medical Service is one part of their support and is built on a pool of general practitioners who are available 24/7 for urgent medical support via the phone and via email for advice(KNRM, n.d.a).

1.2 Company

MedAssist.online initiated this project and the collaboration with the University of Technology in Delft. MedAssist.online is the digital section of the sister company ECMT. ECMT is a medical training centre that trains captains and first mates on Medical first aid and Medical care in line with the STCW regulations. After the training, the trainees receive a copy of a Medical Guide co-authored by Md. W. Boon, the founder of ECMT. Though getting positive responses on the training and the book, the captains did express their insecurities with medical care on board and requesting another solution. Based on this request they started to develop the Skills App(Figure 2), which has the 19 most common skills required on board explained in a video, step by step pictures and additional information like the required tools. The skills app is a more interactive solution which allows for real-time learning during medical procedures on board.

With the skills app, MedAssist.online entered the PortXl accelerator program for start-ups in the maritime industry. From the program, MedAssist.online was able to sharpen its value proposition and decide on the subscription-based sales model and decide on the sales channels. They were able to sign letters of intent for pilots and have since been able to convert these into sales with some large Dutch shipowners like Boskalis, Van Oord and Spliethoff. Next, to the skills app, they also sell a diagnostics tool, the heart app(figure 1). Where the app helps with confidence and accuracy in the treatment, the HeartApp is a diagnostics tool which can make a hospital quality 12-lead ECG. The hospital quality ECG allows for a cardiologist to make a proper diagnosis.
MedAssist.online has made it their mission to provide the best medical care anywhere. Anywhere refers to a broad range of locations like the arctic regions, deserts or on mountains where there is no access to proper medical care. With their involvement in the maritime sector, they say the opportunity here first and are focussed to first built a market in this industry.

Figure 1: Heart app by MedAssist.Online

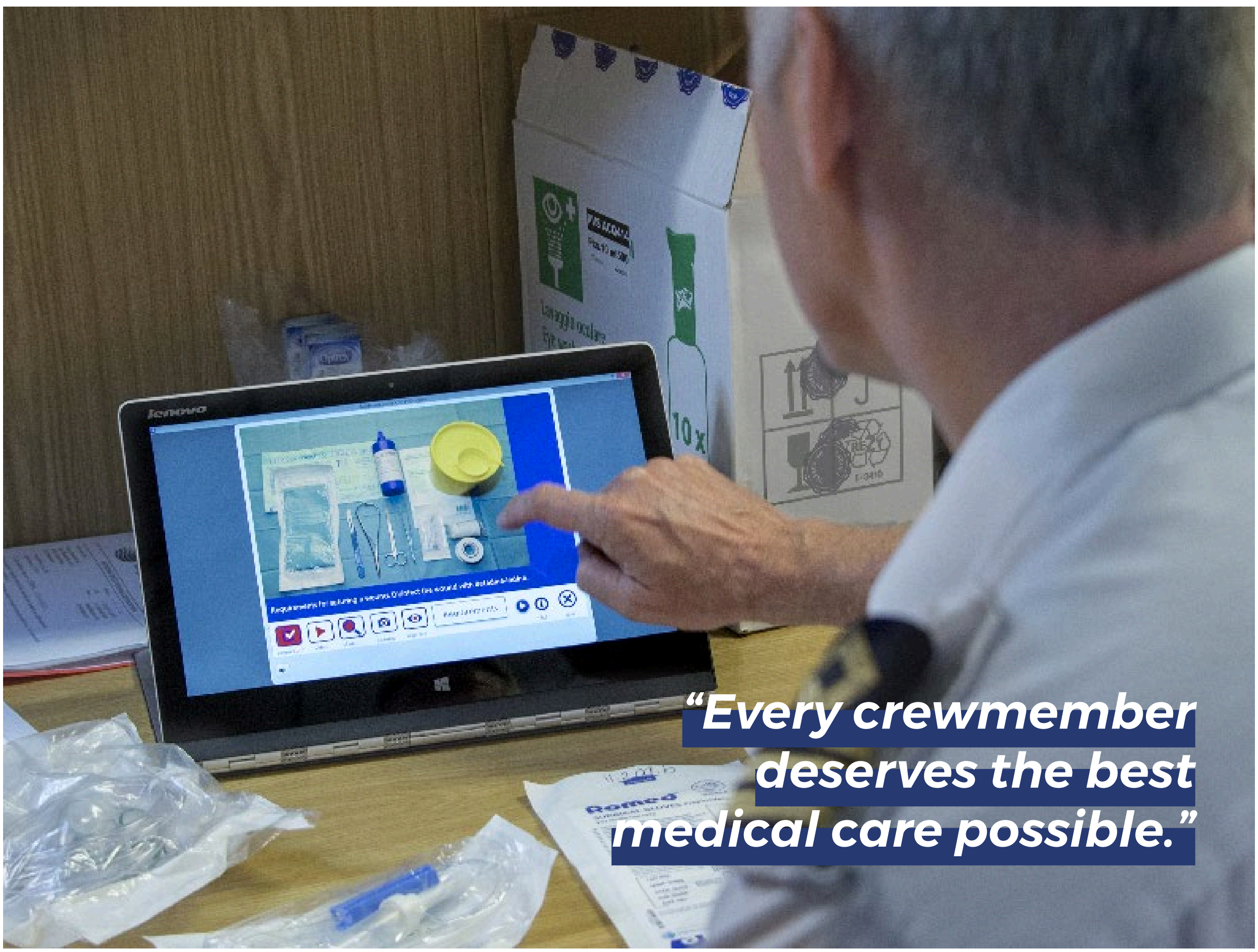


Figure 2: Skills app by MedAssist online

1.3 Assignment

The skills app has received much positive response from the Captain and seafarers who now have this application on board their vessel. One of the strengths of the application is that it works offline much like the book. Making the Skills App an offline product was a conscious decision to make sure the application can be accessed at all times and is not dependent on the unstable satellite internet connections. However, with the global digitisation that is currently taking place, there is more opportunity for more interactive solution potentially also using the internet. In the medical industry, a rapidly increasing application of technology is telemedicine which is an eHealth solution which means “healing at a distance”(World Health Organization, 2010). Another development is the use of Augmented and Virtual Reality and Walther Boon saw an opportunity for this in telemedicine and came up with the innovation of 2-way-AR as visualised in figure 4.

The project goal at the start of the project was to develop a low-cost product-service combination, using 2-way AR, which closes the experience gap between a remote doctor and a doctor standing live next to you when treating a patient with the use of 2-way-AR MedAssist.Online wants to add action to the treatment process by allowing a doctor to support the captain in his skills.

1.4 Approach to project

For this project, a classic double diamond approach applies. In figure 3 the four parts to the diamonds are presented with the activities that are undergone in each of the phases. The analysis phase consists out of two parts. On the one hand, desktop research gives input on telemedicine solutions, and on the other side, the context is explored through interviews and observations. Context analysis and desktop research are combined in test working with the technology to help define the design challenge. From the design challenge, onwards more tests are performed to gain a better understanding of the challenges and the parts to the system. In the concept phase, the parameters of the systems are defined and tested. The results are used as input in the embodiment phase in which the designs are defined in more detail, prototyped and tested to create a set of recommendations for further development.

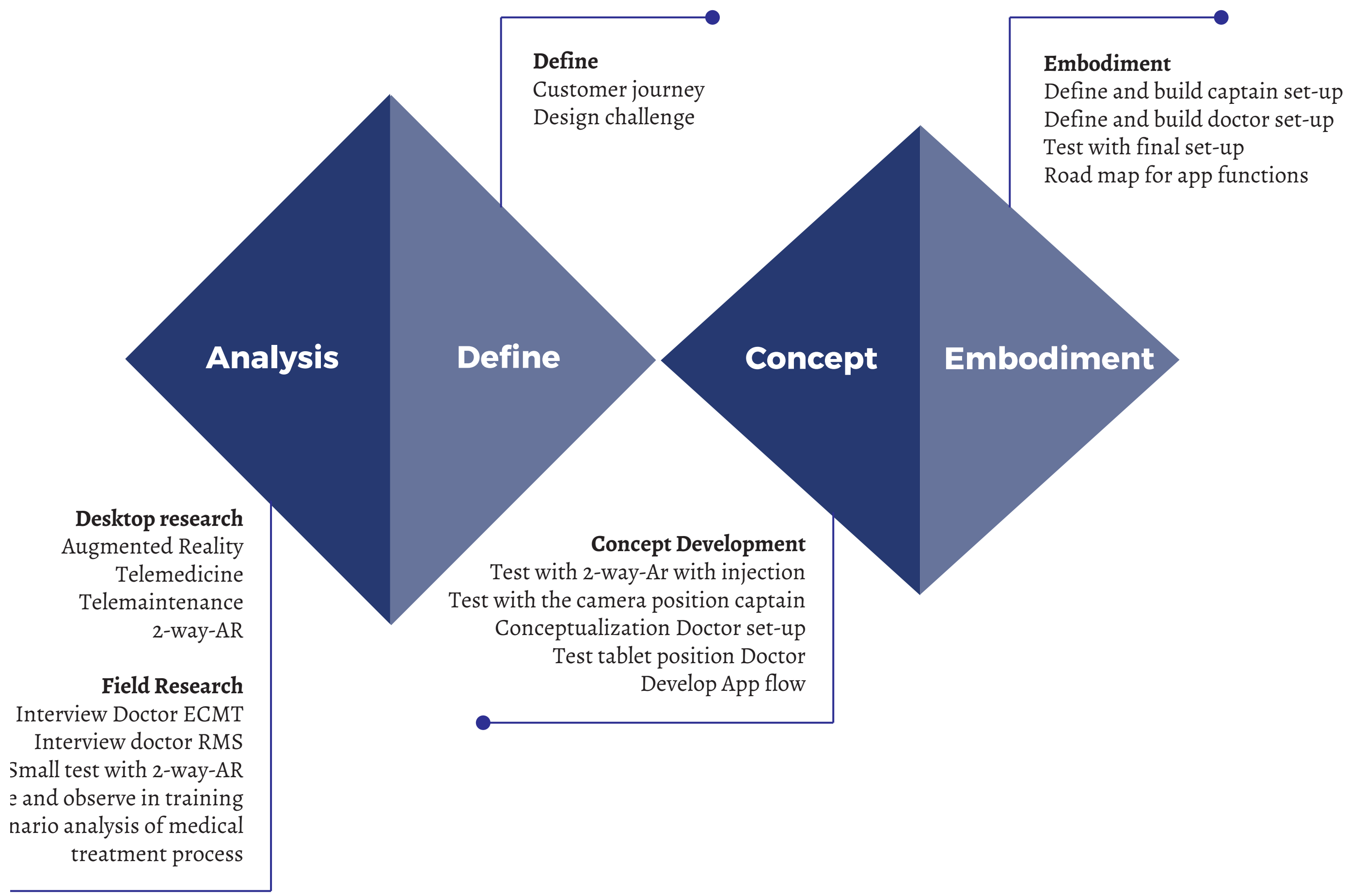


Figure 3: Approcah to project

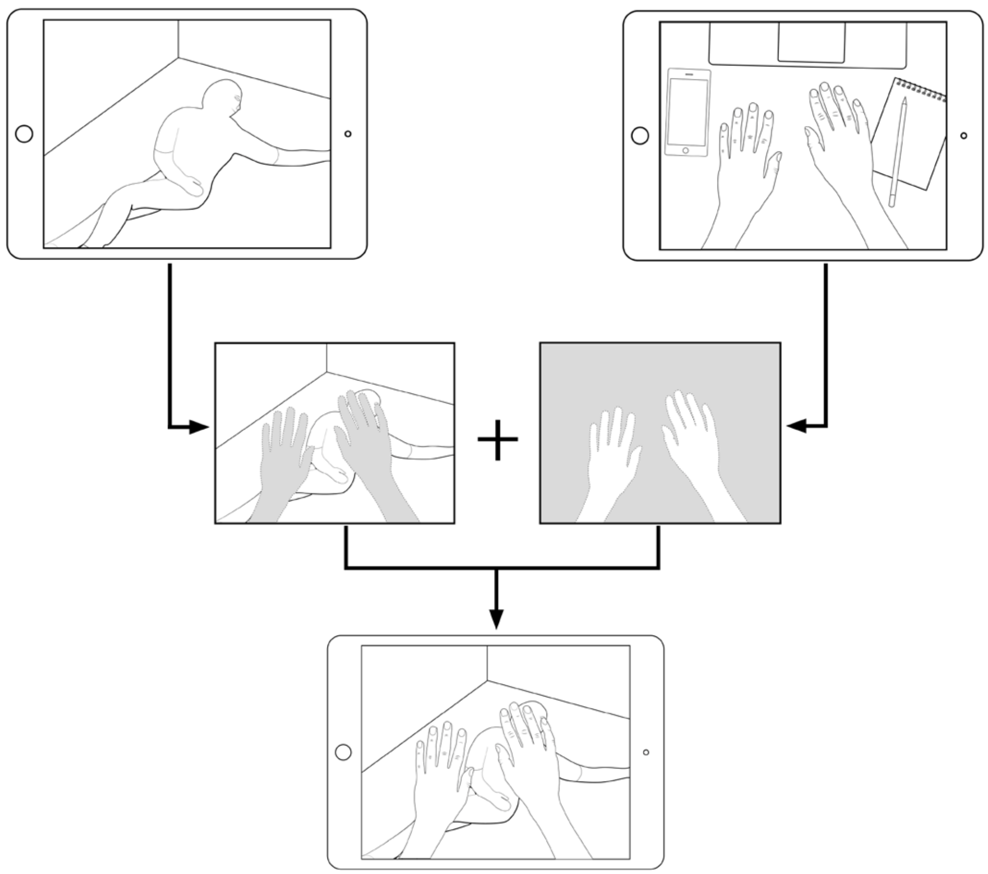


Figure 4: 2-way-AR principal visualised

01
Literature Research

02 Augmented Reality

2.1 What is AR?

Augmented reality superimposes computer-generated information or objects onto the real world(Azuma, 1997; Azuma, Baillot, Behringer, Feiner, Julier, Maclntyre, 2001; Chi, Kang, Want, 2013). This is the basic definition of augmented reality which is similar to the definition in the dictionary: "an enhanced image or environment as viewed on screen or other display, produced by overlaying computer-generated images, sounds, or other data on a real-world environment."(Dictionary, n.d.). The information or images are context sensitive and mix with reality thus complementing reality rather than replacing it(Azuma, 1997; Chi et al., 2013). The overlaying or superimposing of computer-generated images is considered to be AR, however, in the general literature, it is more common to take a more specific definition of AR. Azuma et al. (2001) define three properties AR has 1. AR combines real and virtual environment in the real world, 2: it is interactive and works in real time, 3: AR register real objects and aligns virtual objects with them.

The contrast with the more generic definition of AR is the need for the virtual objects to register and align real world and digital objects so that they interact with the real world. A good example of AR which fits with the generic definition is Pokemon GO(Figure 7) which show Pokemon in a filmed view. Now there are explorations of Pokemon GO where the app recognises the environment and the Pokemon runs around the table(Figure 6) which fits more with the academic definition.

2.2 History AR

According to Bilinghurst, Clark and Lee(2015) people have been using mirrors and lensed to create virtual images in the real world. Ivan Sutherland developed the first known real development of interactive AR with a head-mounted display, tracking system and graphics generator(Bilinghurst et al., 2015). Another excellent example of an early AR development is the fighter pilot helmet first researched by Furness(1986). The research focussed on controlling the information stream to the fighter pilot by using the cognitive abilities without overloading them.

With the evolution of technology and digitisation of the world the computing power is increasing while the size of hardware is decreasing, these developments have propelled the research into AR and are increasing its widespread application. In figure 5 a timeline of the developments in AR is presented with some of the breakthroughs in AR. Based on the four phases identified by Bilinghurst et al. (2015) and a summary image by Augment.com(n.d.) aided with examples from more desktop research.

The first phase Bilinghurst et al. (2015) defined the pre 80's like the phase where the first experiments took place which in the future would define AR. In Figure X this means having the first AR installation with a heads-up display by Sutherland in 1964 and later by Myron Krueger in 1974 who used projectors to immerse the user in an interactive environment. (HuffingtonPost, n.d.).

After the '80s, it was not until the mid-90's that AR moved from experimental installations research, also in the enabling technologies like tracking and display and input devices(Bilinghurst et al. (2015)). One of the first and well-known developments in this time is the fighter pilot display, first researched in 1986 by FURSTENHORST(1986) with the first iterations of a head-mounted display and iterations of what the digital environment could be. Later developments of this research were even used to help NASA visualise and land space shuttles. This is also the phase in which Caudel and Mizell(1992) are credited with the introduction of "Augmented Reality". Sutherlands(1964) initial research focussed on improving man-machine communication from a line based on imaging and movement based, this was not initially about introducing a new interaction with the world. As mentioned it is in the mid-1990s that the research into enabling technologies is takin off.

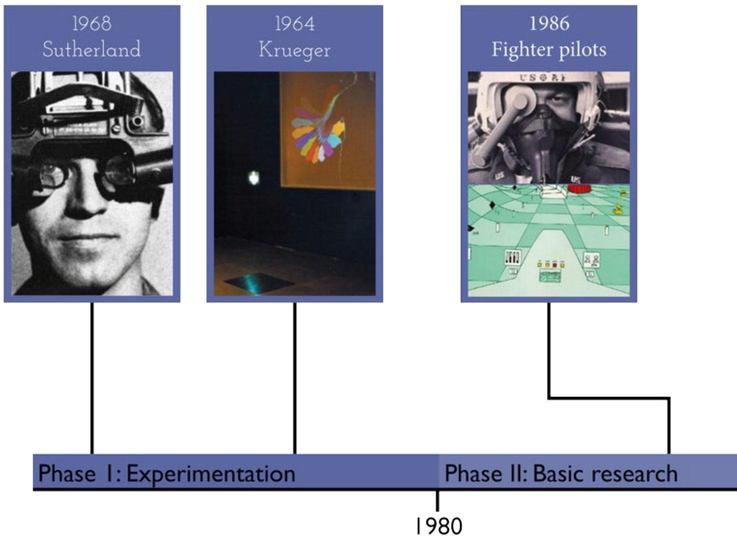


Figure 5: History of AR

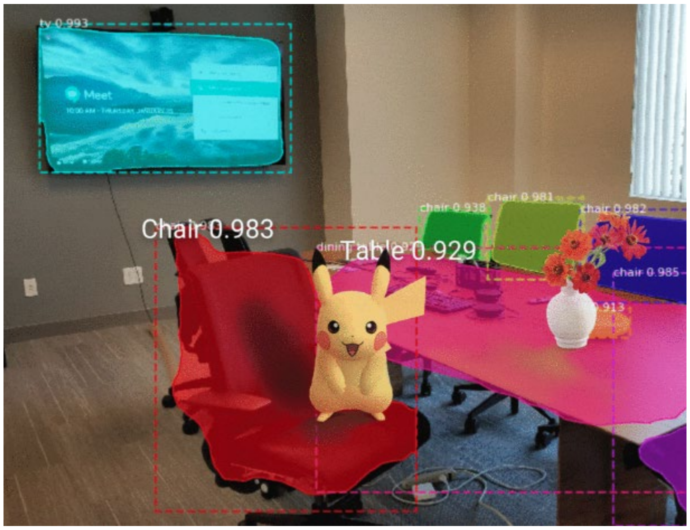


Figure 6: New AR functionality pokemon go(Melnick, 2018)

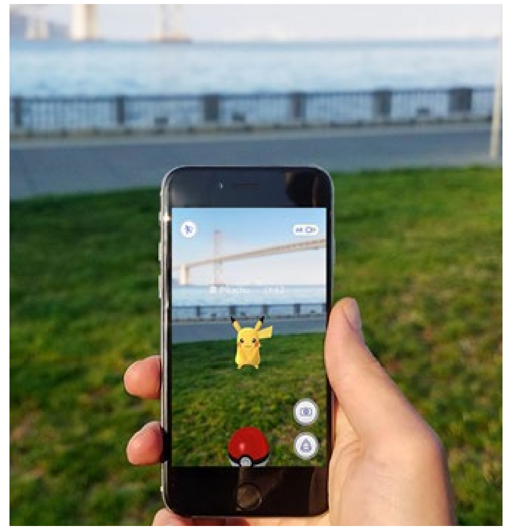
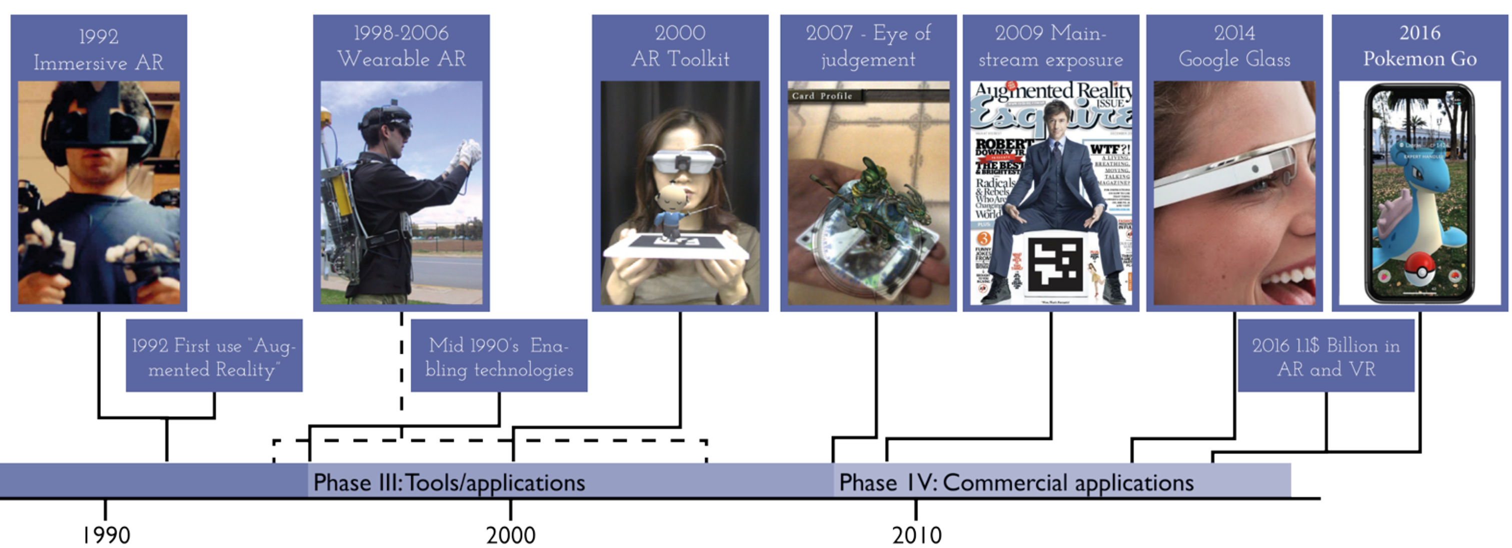


Figure 7: Pokemon GO

The development of these enabling technologies is what pushes the development of the next phase(mid-1990's -2007), where AR enabling technologies are used to interactions and usability of AR(Bilinghurst et al. (2015). The push into interactions and usability is aided for example by the development of the ARToolkit, which was the first to make marker detection available as development for developers as an easy tool to develop AR applications. The AR-Toolkit was the first 'cheap' and small method for the tracking of real-world objects and relate these objects to the point of view(the camera). The wide availability of this toolkit, and more paved the way for the commercial application of the AR.

It is for this reason that the third phase ended so exact in 2007; it is in this year that the general public got to experience the applications of AR. TV programs start using the yellow lines on sports fields like in swimming and American football to show previous times and the first down the line. The other mainstream application was the introduction of the game Eye of Judgement on the ps3. This game used a camera to recognise playing cards and display an animation on TV above the playing card. From gaming, it went on to 2009 when print media, the magazine Esquire, used AR to bring life to its cover. From there on the applications have grown exponentially. The widespread exposure of AR is recognised by Bilinghurst et al. (2015) as the fourth



phase in which a wide spread of commercial applications is starting to develop. In the present time of writing this article, we now have the google glass and Pokémon Go which has exploded the mainstream familiarity with AR and boosted the investments to 2.3 billion USD in AR/VR 2016(DigiCapital, 2017).

2.3 AR vs. VR

Virtual Reality seems to be the better known big brother of augmented reality. The number of examples and level of understanding seems to be much higher with the general population. Potentially because VR is more immersive and thus triggers the imagination of people and there have been many examples in gaming. AR seen on TV is potentially not questioned so much what it is or does because the first applications integrate reasonably seamlessly with reality. There are many articles on the internet explaining the difference between the two, which adds to the suggestion that people are familiar with one of the two or both but cannot see the differences.

Though AR and VR are often compared to explain and understand the similarities the two could almost not be further apart. This becomes clear when considering the “Virtuality Continuum” introduced by Milgram and Kishino(1994) visualized in figure 8. Augmented Reality is all the way on the left of the spectrum because it maintains full connection with reality while superimposing a digital imagery, related to the real world, over the real world to enhance the usual perception. The addition of adding virtual information is just one step from actual reality. While virtual reality loses, visually at least, all connection with the real world and presents an entirely simulated environment disconnected from the real world view(Asschenbrenner et al., 2016), on the continuum the two can hardly be further apart, it is important to realise that VR is an entirely artificial construct(Asschenbrenner et al., 2016). Based on the definition AR and VR are very far apart, but in practice, there are cases when they grow closer together as we will later see.

Similarities
Firstly AR and VR both make use of similar technologies like HMD’s and display technologies and feature similar software(The Awe, 2017; Chavan,2018). Secondly, both are used to create an enriched and new user experience especially focussed on a change in visual information. Lastly, both innovations are often used interchangeably due to the developments and potential in similar markets like gaming, medical and army. AR and VR have both been massive in gaming due to the experience enhancing abilities. At the same time both are used for education purposes, process improvement and medical scenarios(The Awe, 2017; Chavan,2018).

Differences
The first difference, as mentioned before, is the use of reality in AR and the creation of a new reality in VR. VR is almost solely with HMD’s which isolate the eyes from any real environment input and only leave the artificial environment often with tools to control the new environment(The Awe, 2017). AR requires a camera to get input from the surrounding environment to be able to link the digital enhanced information to the reality of the user, for VR this is not a requirement it just needs a display screen(Chavan, 2018). For VR the display screen is almost solely in HMD’s while AR has the freedom to use a much wider range of devices.

2.4 Types of AR

For AR there are three basic methods to present AR; Video see-through, optical see through and projective(Krevelen & Poelman, 2010).

Video see through
Video see-through is the cheapest and easiest to implement of all AR types. It is the type which is closest to the virtual reality because the real environment is filmed, presented with as a video feed with the AR as an overlay in the digitised images(Krevelen & Poelman, 2010). A well-known example of video see-through AR is Pokémon GO(Figure 7). The use of one device which has filming and display capabilities to capture the real world and add images to this.
An advantage of video see-through AR, apart from being the cheapest method of AR and easy to implement, video see-through allows for the simple mediation of objects from reality because a digital representation of reality is given(Krevelen & Poelman, 2010). Filming reality and digitising this and adding AR to it also allows for the reality and the AR to blend in smoothly by matching brightness and contrast(Krevelen & Poelman, 2010).

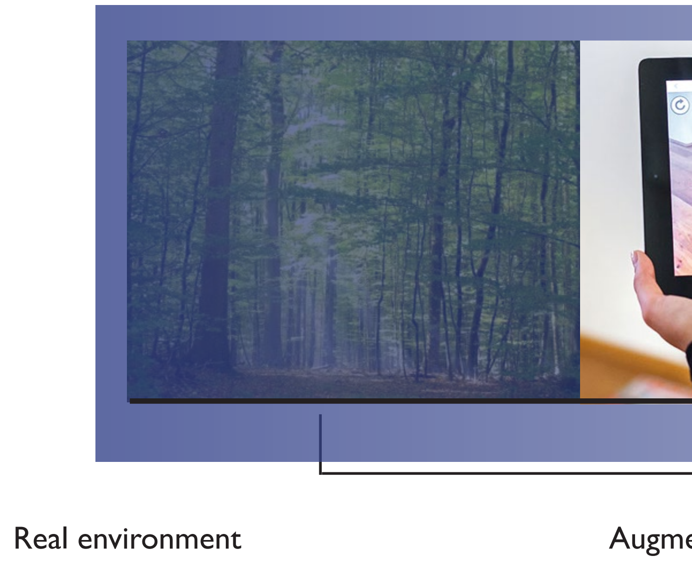


Figure 8: Virtuality Continuum based on Milgram & kioshino(1994)

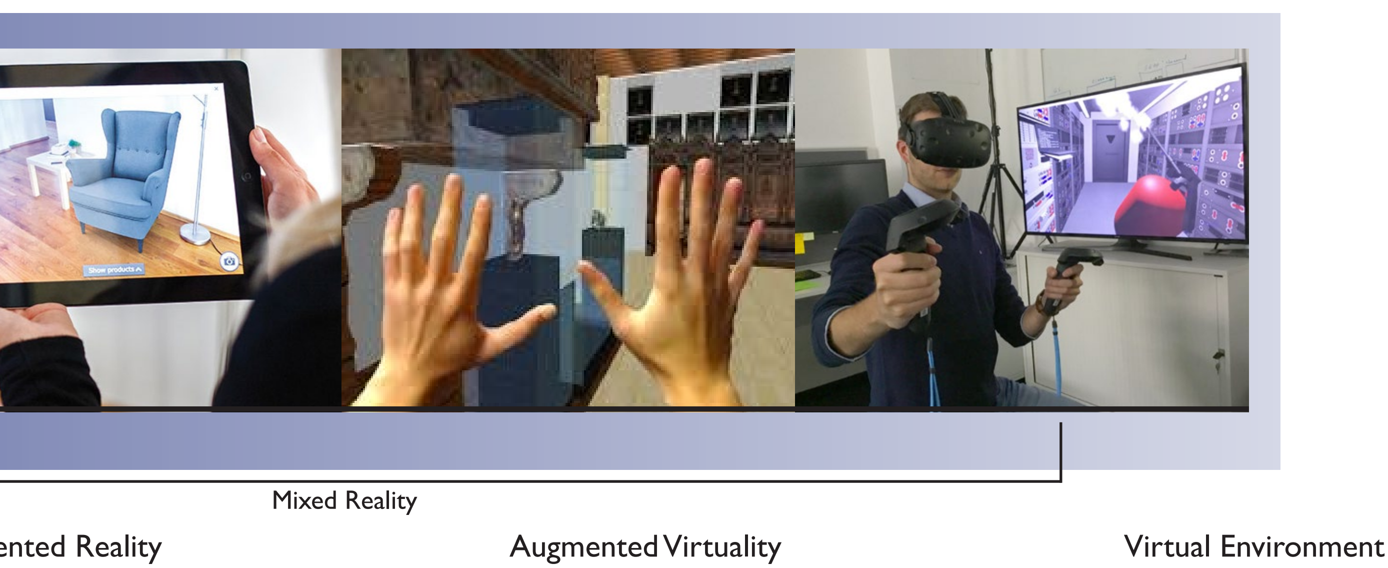
Filming and digitising the real world also has disadvantages since it reduces the resolution of reality and can, depending on the hardware and connectivity, delay the display of reality(Krevelen & Poelman, 2010). The combination of the camera and use of a display limit the field of view while at the same time creating a discrepancy between the perceived reality by the eyes and displayed on the interface(Krevelen & Poelman, 2010).

Optical see through

Rather than displaying a filmed version of reality, optical see-through AR leaves the real world intact and displays only an AR overlay using transparent mirrors and lenses. An excellent example of this technology enabling this method of AR is the HoloLens. An example of an application on the HoloLens as displayed in Figure 9 is an excellent example of optical see-through AR.

Optical see-through AR has some significant advantages over video see-through AR. With optical see-through AR, the resolution of the real world is left intact, and there is no parallax between the eyes and camera or screen(Krevelen & Poelman, 2010). An added advantage of the transparent lenses and mirror is that it never will obstruct reality even if the power fails.

Because the real world is left intact but overlaid with holographic images, it is hard to exclude real-world objects from the view while at the same time the overlay can reduce the brightness and contrast of the real world perception(Krevelen & Poelman, 2010). Also for optical see-through, only a limited field of view can be achieved, and there is a need for additional input devices(Krevelen & Poelman, 2010).



Projective

The last type of AR is projective AR which, rather than sub imposing images digitally as if they are connected to the real world, actually projects imaging on the real world environment.

Using real-world objects and project on them makes it comfortable to look at and allows for a full field of view by covering large surfaces with the projections(Krevelen & Poelman, 2010).

Unfortunately implementing projective AR has only limited use cases. This type requires a projector for the AR and a camera to perceive the environment, and it needs to be used indoors because of the need for high brightness of the projection to be able to achieve enough contrast(Krevelen & Poelman, 2010). At the same time it is almost impossible to exclude objects from the environment since these act as the canvas, and if there is anything in the way of the projection, this will influence the AR experience.

In the figure below there is a great interactive example of the ability of projective AR. Moving the sand in the sandbox triggers the software to draw contour lines much like on a map(figure 10). By obstructing the projection as shown in the figure the user can make it rain. So obstruction of the projection can also be an interactive opportunity. Another challenge with projective AR is the recalibrating of the projection if the objects or position of the projector changes. For the sandbox, the 'eyes' of the system and projector have a fixed distance from the sand.

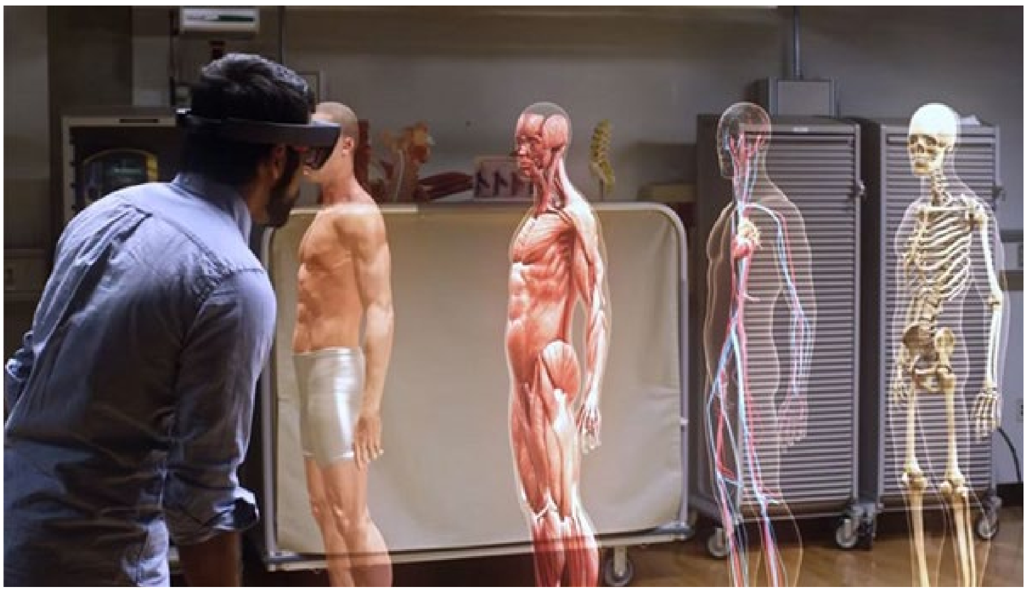


Figure 9: Experience of microsoft hololens ("Augmented reality in Medicine Field", 2016)

Figure 10: Ar Sandbox ("AR Sandbox", n.d.)

03 Telemedecine

3.1 What is telemedicine?

Telemedicine is defined as "Telemedicine (also referred to as "telehealth" or "e-health") allows health care professionals to evaluate, diagnose and treat patients in remote locations using telecommunications technology."(AMD Globalmedicine, n.d.). Craig & Petterson(2005) give a less functional definition and define it as "...the delivery of health care and the exchange of health health-care information across distances."(Craig & Petterson, 2005, p2). The authors continue by explaining that telemedicine can be classified on two parameters. The first being the type of interaction between the client and expert, is it live or pre-recorded and the second the type of information that is being shared, is it text audio or video.

Craig and Peterson(2005) stress heavily the notion that telemedicine is not some sort of new technology or branch of medicine which will solve all medical challenges. It can be a valuable addition to current medicine activities.

Though hard to pinpoint, the advancement of telemedicine started when telecommunications evolved. Craig and Peterson(2005) mention the first examples are casualty reports being communicated in the second world war. But the real advancements have been taking place of the last 20-30 years in parallel with the increasing availability of telecommunication and the internet is has become more common.

3.2 This thesis

Reviewing the definitions from AMD Globalmedicine(n.d.) and Craig and Petterson(2005), it can be concluded that this project can be considered as a ehealth or telemedicine solution. Using the internet to share video and audio data with healthcare information to diagnose and treat patients. The only addition is the Captain who takes on the role of a medical actor and communicates with the medical expert.

3.3 Advancement telemedicine

In a systematic review of telemedicine in the early 2000's Hailey, Roine & Ohinmaa(2002) identify that the effect of telemedicine was showing some value in medical consultations, teleradiology and telemental health. At this point, the authors do point out these results are mainly from pilots and short-term outcomes. Craig and Peterson(2005) identify cost savings as one of the potential benefits of telemedicine. Unfortunately, the cost savings have not yet been proven. There have been reports proving that alternatives for face-to-face consultations with patients are feasible, but the potential economic and medical benefits are not yet conclusive(Currell, Urquhard, Wainwright & lewis, 2000). In 2010 the lack of proof of long-term positive effects of telemedicine was motivation for Ekland, Bowes and Flottorp(2010) to do a large scale systematic review of systematic reviews which reviewed telemedicine literature. Within the review, the authors found 21 studies which conclude that telemedicine is effective.

Technological developments are integrated for improvement of care, but the bottom line remains that they have to be cost-effective and preferably cost beneficial to be implemented. With telemedicine, the cost-effectiveness has not yet been proven(Whitten, Mair, Haycox, May, Williams, & Hellmich, 2002). This is an older study(2002), but it does show that there are challenges to be overcome — the MedAssist.Online service will have to have a strong business case behind it — the advantage with the market focus of MedAssist.Online is that it is extremely remote and not replacing a face-to-face interaction but upgrading a minimal telemedicine solution with the RMS. Medical outcomes and quality of life are always hard parameters to quantify in money, but in an extreme situation, an evacuation or rerouting of the ship could be prevented saving 10 000's of euros.

Globalmedicine(n.d.) does not refer to the economic benefits of telemedicine directly but focusses more on the remote care opportunities. The lack of needing a physical location or bringing care to people who are not near enough to medical care. This focus is more in line with the benefits this project is trying to capitalise on. Of course, there is always a business case to be considered, and up to now, many solutions try to improve the current business case by replacing face-to-face care. There is a huge opportunity with telemedicine to provide care to those who have no access.

Telemedicine in the papers reviewed above is stooled on sharing information digitally between experts, remote monitoring, and digital consults with patients and other medical interventions(Ekland etal., 2002). The interesting discrepancy with the service that is being researched and developed within this project is that the communication is between a medical expert and a semi-trained medical actor, the patient is the object of conversation. This discrepancy makes for a much strong parallel with telemaintenance as will be explored in the next chapter.

3.4 Competitors Telemedicine

Telemedicine is not a new development ever since the development of telecommunications there have been developments in telemedicine. Over the last two decades, the developments have picked up with the further enhancement of telecommunications and technology. The development of telecommunication has given rise to telemedicine services, some maritime specific, which are competitors of the 2-way-AR service.

There are many solutions available which allow the patient to call a doctor and have a live, video conferencing consult. Especially in the US their many solutions from tech start-ups and established healthcare providers and hospitals. Examples of these services are Chiron Health(2018), Dr on Demand(2018) and SatMed(2018). In essence, they all provide a similar solution allowing to book an appointment or request a direct consult; the service is backed by a group of doctors who will accept the appointment or call back. Through the live video conference, they can make a diagnosis and give, limited, advice about medication. There are some differentiating features or market focusses. For example, iDoc(2018) is specialised in advising on skin conditions by reviewing photos. Another great application, which is not just about live consultation, is Babylon which uses AI to review a health check or symptoms and gives information and advice for a video consults based on AI.

The telemedicine solutions described above are of course for remote care in the sense that the doctor and patient are not in the same room. However, they might be in the same country, state or even city. They are not exclusively built on remote care for hard to reach location like for example the artic or sea. For this industry, there is a whole other group of competitors. These competitors, rather than providing just the digital platform, they have a whole kit with all the hardware required to help with the medical consult.

The first service with kit is DigiGone's five plus telemedicine kit which can be found in figure 11 with all the hardware inside(Digigone, n.d.). Digigone's kit is designed to support multiple scenarios from emergency care which requires real time communication to home health care visits to monitor a patient's progress(DigiGone, n.d.). It has multi-party video calling capabilities and encrypts all live data which is also shown live on screen during the call.

VSee's telemedicine kit is less elaborate, and they also claim to be the easiest telemedicine kit for remote consultations(VSee, n.d.). As can be seen in figure 12 the kit is considerably smaller with less hardware. The kit can be found on Shell's oil platforms of the coast of Nigeria and Alaska.

The elaborate kits give a lot of opportunities for better diagnosing, much like the HeartApp by MedAssist.Online. It does raise the question if these kits need to be operated by a experienced medical professional. The kits allow for a lot of data collection and use a tablet or laptop to set up the live video connection. The kits do not seem to provide any support in the actions of the treating professional, it is all about diagnosing and communicating, this is where the 2-way-AR service can set itself apart. The other differentiator is the lower cost at which the service over tablet can be sold due to the lack of need for hardware.

3.5 Why is 2-way-AR a valuable opportunity to apply in telemedicine?

Looking at the 2-way-AR service the value of adding this service is firstly providing remote care. The remote care is now provided by phone, with this service there is the opportunity to communicate live video and audio. The live video and audio give the opportunity for the doctor to create a better diagnosis and give more accurate advice to the captain. Up to this point, the service is like any other telemedicine which offers video conferencing. The addition is the 2-way-AR functionality which gives the opportunity for the expert to give better instructions and through this improve the care.

Components
The Five Plus includes-
- 10” Windows Tablet
- Bluetooth Thermometer
- Bluetooth Pulse Oximeter
- Bluetooth Blood Pressure Monitor
- Bluetooth Blood Glucose Meter
- Bluetooth Single Lead ECG
- Bluetooth Keyboard
- USB Macro Camera
- Hands Free Speakerphone
- USB Ethernet Adapter
- 3x USB ports
- Multiple Power Input (110/220VAC/12VDC)
- Built-in Wi-Fi g/n
- Crosslink insert with water resistant case

Figure 11: Digigone telemedecine kit(Digigone, n.d.)

Figure 12: VSee telemedicine kit(VSee, n.d.)

04 Telemaintenance

4.1 What is telemaintenance?

Telemaintenance does not have a definition in the dictionary, and there is no generally accepted definition. Sanchez, Fernandez, Vena, Carpio & Castro(2011) have used the a definition which:"...includes all the maintenance actions based on the capabilities of remote supervision and activation of given equipment in an industrial environment." for their paper on remotely controlling equipment (Sanchez et al., 2011, p1). This thesis is more focussed on the remote support of technicians by an expert with AR like Masoni, Ferrise, Bordegoni, Gattullo, Uva, Fiorentino & Di Donato(2017) do in their research. Masoni et al. (2017) do not use the term telemedicine but rather remote support which is possible because of the rise if industry 4.0. The industry 4.0 is the digitalisation of the industry and increased use of cloud-based solutions and internet communication. For industry applications,, remote supervision and control does not have to refer to a person but can also be a machine. The key is that it is remote.

4.2 'Tele' in telemaintenance

Webel, Bockholt, Engelke, Gavish, Olbrich, & Preusche(2013) identify that experienced service technicians are a vital asset in a company's daily operations and production. The authors identify that experienced technicians knowledge is hardly ever documented and is concentrated in a small group of technicians. To create cost savings companies can document the knowledge in text, images and video and share them with the rest of the technicians. However, as Webel et al.(2013) identify, that the use of text and videos has its limitations at it only allows to capture

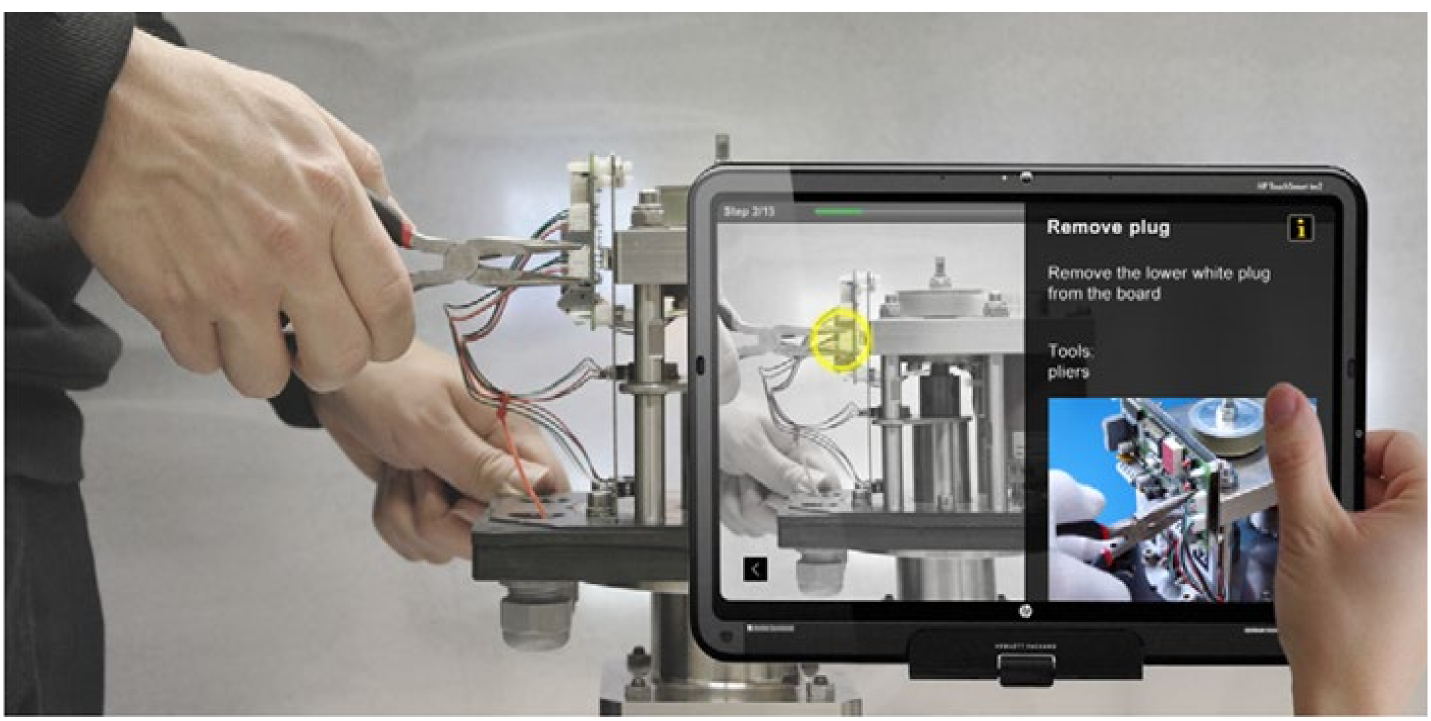


Figure 13: Telemaintenance training solution(Masoni et al.(2017)

Figure 14: Telemaintenance conferenccing with remote expert(Masoni et al.(2017)

set scenarios and with that it is hard to capture the accumulated knowledge of the expert to deal with a wide range of situations. Webel et al. (2013) propose a solution to this limitation by combining the strength of pre-recorded AR maintenance scenarios and the opportunity to receive live support. There are four steps to the system: 1. Capturing, rendering, the rendering is the showing of a 3d animation which is superimposed on the live feed(Figure 13). If a problem occurs he can set-up a live connection and the trainer receives the live feed and can reproduce the training set-up and problems and adapt the training protocol or add information with drawings(Figure 14). Having a remote expert who can be consulted when in need is similar to what Masoni et al.(2017) suggest so that one expert can support multiple less skilled actors.

Kleiber & Alexander(2011) make an interesting claim that a typical telemaintenance session has two parts: a problem analysis and problem solving. In training set up as seen in Webel et al.(2013) there is a limited need for collaboration. Kleiber & Alexander(2011) assume that expert support will increase the performance of the technician. The authors, do, however, identify the limitations to the interactivity of teleoperations which could negatively affect the performance.

4.3 Similarities telemedicine

The opportunity for AR in industry settings have been identified since the birth of AR(Azumi, 2000). Research described above are examples of the value of AR in as a learning tool and as remote support tool where an expert can be consulted and influence the AR experience.
In telemaintenance there is similar to the context in this project there is a trained non-expert handling a situation with the support of a remote expert. There is one important difference, the subject of focus in the context of this project is a patient rather than a machine for example. Overall it can be argued that telemedicine and telemaintenance using AR are similar use cases.

MedAssist.online has taken the first step in making expert knowledge available with the skills app. According to Webe et al. (2013), this is the first step to cost reductions. The limitation is the static nature of the instructions which can only show specific scenarios. With the 2-way-AR application, MedAssist.online is making the step from an eHealth solution to a telemedicine solution.

05 **2-way-AR**

2-way-AR is an invention by Walther Boon and is currently in the process of being patented. With AR, since it is on the left side of the Millgram spectrum, there is always a strong connection with the reality the user is in. It is never fully immersive like VR, but the reality is augmented with additional information or imagery.

Some of the examples directly put information in front of reality like heads-up displays in cars or the google glass. Sometimes this is context specific, or just information like the google glass does. This can be automatic if the device can recognise the surroundings and adapt the information is shown to this, and sometimes it needs input.

A growing development is the use of augmented reality in telemaintenance, where a remote expert can add information to the view of the less trained person who is on location. This is often done by drawing on a tablet or computer to give instructions with arrows and signs.

Two-way-AR is different as it combines two realities into one new. This is schematically visualized in Figure X. There are two locations, in this case with tablets(Device A and B in figure 15), and both are filming a reality. These two realities are both parts of the new augmented reality which is then presented at both locations. The combining of two realities into the third creates a new, digital, shared reality. This is different from current applications of Augmented reality. Current AR application as seen in the telemaintenance industry use one reality to which they add images on.

In the current set-up, there is a rather old method used to control one of two realities, and this is green screen technology. Using a green screen in combination with software code to eliminate the green areas allows for one of two locations' reality to be controlled. If not, the merged view would only be the superimposed view since both realities are used 100%. In Figure X, there is a more graphical representation of the 2-way-AR process in the context of this project. The hands are cut out of the reality on one side and superimposed on the other reality to create a new augmented digital shared reality for both sides.

The benefit of this way of using AR is that that it is possible to use objects and hands to communicate between the two locations. Rather than having arrows and drawings, which can only point and clarify, the expert now has the opportunity to show what to do rather than suggest.

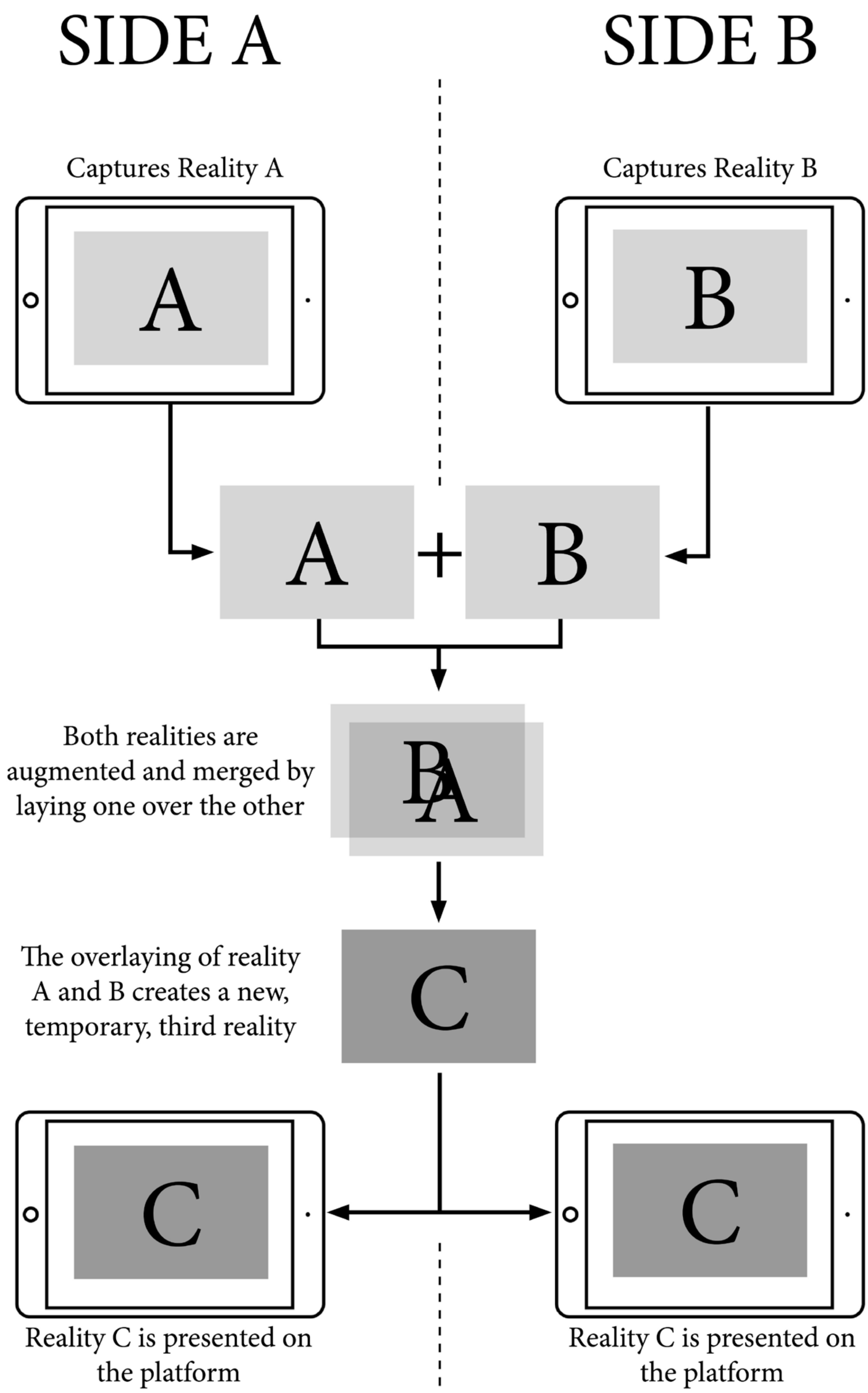


Figure 15: Scematic representation of 2-way-AR technology

02

FIELD RESEARCH

06 Context

You are the captain on board of a ship ' Imagine you are a 1000 miles out' you are responsible for the care of your crew, and there has been an incident on board. This is the introduction to pitch used by MedAssist.Online to help the listener understand the situation of the captain. Under the new regulations of the STCW as a captain you have had one week of medical training. The training took place more than two years ago and one of your crewmembers, who is more often than not a close colleague or even friend, has just cut himself badly in his leg with an angle grinder. The cut is roughly 8 cm long with rough edges and is bleeding heavily; it is now up to you to make sure he is treated the best way possible.

The limitations of the situation are that it is on a ship, far out at sea. The boat could be rolling around; the patient could be in a hard to reach spot or even in a dangerous situation. These could all be adding stress and pressure to the situation. At the same time contact with the mainland is limited with satellite internet and phone which can be heavily influenced by weather conditions.

The captain of the ship is responsible for the medical care of his crew on the ship. Both the captain and first mate should have the required level of training to be able to provide medical care on board. To take care of an injured or ill crewmember, they are required to follow one week of training per five years during which they learn the skills to stabilise the patient, measure and analyse the patient, communicate with the RMS and to perform the skills to take care. As one can imagine the captains and first mates do not always feel adequately trained to deal with the wide variety of medical scenarios, the come across and are looking for support. At the same time, the safety and well being of his crew is not the captains only responsibility. This was already touched upon in the introduction, but the captain also has responsibilities towards the ship owner about keeping to his schedule and staying cost efficient.

The shipowner is the company who owns and exploits the ship. They are the authority the captain answers to, and they have the responsibility to make sure the captains and first mates have the right support to provide the best medical care. The support consists of training and the required tools and medicine on board but can go beyond with additional tools and for example telemedicine solutions.

In the current regulations they have to aim to achieve the same level of care at sea as on land, but since this has not been specified in detailed requirements, it is up to the shipowner to implement what he deems relevant. Because the primary interest of the shipowner is to keep costs low and make a profit it can be the case the only want to meet the minimum set of requirements.

Their interest is to have the shortest transport times so they can take new assignments and have no loss of customer satisfaction nor do they want to incur extra costs from the delays. For this they need a healthy and injury free crew who can keep working and not need to be evacuated or dropped off at the closest harbour. Any delays from injury which require re-routing can cost up to 180 000 euros per day.
Safety of crew is a key component in ship management and should always trump costs. Unfortunately the cost pressure does push the safety considerations back. In the interview with the RMS doctor(Appendix C) he told an anecdote where he advised evacuation of the patient. The ship, at that moment, was close to the Algerian border which is not the best place to go on land, was advised to head north and evacuate there. Later the doctor found out the ship continued its journey and the patient was taken off five days later. Time pressure on board of the ships is very high.

The medical specialist receives the incoming call from the captain, much like the current situation with the RMS. Usually, the RMS interprets the information to provide through the phone by the captain. He uses the information to ask more specific questions and maybe have the captain get more data on the patient. He uses this information to form a diagnosis and advice the captain on the next steps of care. The main interest of the medical specialist is twofold, first to get the best quality of info on the patient to form the most accurate diagnosis and second to give support to the captain to take the necessary actions.

The captain is the manager of the ship with multiple responsibilities ranging from adhering to the schedule, communicating with the owner, making contact with harbours as well as medical care and safety on board. The availability of captains throughout the year at the training centre gave the opportunity to engage with them and observe them during training.

Rresults interviews

The first questionnaires(Appendix A) with the captains did not yield the expected results as the captains were fairly closed in their answers. It was also the case that not all of them were often in touch with medical incidents because they work on ferries, but do need the training. The results in (Appendix A) were so minor a new approach had to be taken. The limited response was not entirely unexpected as colleagues also mentioned this as the dominant culture on board. One of the captains experienced one of his crew being in a heart attack; it did not phase him at all, he pointed out they gave him a pill and that was it.

To get more out of the captains, they were made part of an experiment so that they were in a more active and talkative. Having them perform some actions to make them more engaged worked on one of the two participants, the other not so much. Captain B(Appendix A) was very confident in his skill and would only value the confirmation of a live connection. Captain A came with an insightful anecdote, after first saying he only experienced minor incidents, he explained he once misjudged a heart attack and the woman past away in the night which is of course very serious and proves the challenges these captains and first mates in remembering and applying their training. He also had a crewmember with a cut in her foot from a piece of glass. He got so nervous and did not remember how to stitch. When he practised the crewmember said, "you are definitely not touching my foot". So, they bandaged it and got her to land the next day. He experienced also pressure from the people on board who all expected he knew what to do. He claims it was ' spanned' nerve-wracking in English, "You do not remember everything or all skill. It is tough to know if you are doing it right".

First small test with AR

A small test was performed with the AR app, to see the functional performance of the app was an opportunity to get a captain's thoughts on the value(Appendix D). The results of the test immediately go into the direction of the feeling of support. The captain felt it could take away insecurities and the voice has a calming effect. He even suggested adding the face of the doctor to the communication to add even more of a positive feeling(Appendix D).

First needs

The doctor working at the training centre pointed out in his interview that the primary value of the RMS is the feeling of sharing responsibility(Appendix B). This was also a result from the first small test with AR where the captains immediately point out the most significant value are the communication and confirmation. This confirmation can help with the support of skills, this was pointed out by the trainer but also clear from the anecdote of the captain who felt very uncomfortable and was unable to perform. They need support so they can feel confident and actionable.

- Sharing responsibility (doctors say this)
- Support in skills with confirmation (tips and coaching Jeroen says)
- Feeling of support

07 Doctor

Part of the training for the captains is a day on the wide variety of symptoms they might come across. This part of the training is always done by a medical doctor, while a medical professional like a nurse usually performs the rest of the training. One of the doctors was interviewed to get the first understanding of the doctor's needs(Appendix B). Though a well trained professional working often in the maritime context this doctor has no experience being a Radio Medical Service doctor, To compensate for this lack of experience a Radio Medical Service doctor was also interviewed to get better insights into his specific needs and experiences with remote care in the maritime sector(Appendix C).

Dr. van der Leer explained that the RMS doctors are general practitioners who do this as a side task parallel to their jobs. They rotate with five doctors, meaning they roughly fulfil one week of shift per 5 weeks. During these, they are available 24/7 and for this always carry a beeper and iPad. Per week they roughly take care of 12-20 cases of Dutch ships in international waters or any vessels near the Dutch coast. At the moment much of the communication with captains takes place via Email, and he sometimes wonders why they even call. A phone call is a significant intrusion on his work. There are priority levels to the requested support, but he says he hardly looks at them and calls as soon as possible. When there is a need for an evacuation, he drops everything. About service

The responsibility and role of the RMS doctor are forming a probability diagnosis according to the dr. Van der Leer and medical support in general. Sometimes there is no need for a diagnosis if it is just a question, ill or people do need a diagnosis and plan for treatment. He clearly states that it is not his responsibility if the treatment is followed up.
There was one case where he advised to evacuate the patient. However, this was around the coast of Algeria, so he advised going north and arrange evacuation as soon as possible. In the end, the patient was taken off five days later in the Adriatic sea. It probably did not work for the ship.
As a RMS doctor, Dr. Van Der Leer does not have direct contact with the patient because he is not the responsible caretaker of the patient: "The first mate is the spokesperson, and I am a supporter of him, not a direct caretaker of the patient". Though there has been a recent ruling that there is 'treatment relation'.

The doctor from ECMT pointed out that the most significant value of the RMS is the ability for the captain to share the responsibility. He says they learn a small number of endless scenarios, so they are most likely out of their depth and in need of support. The RMS service doctor believes the most significant value is more functional with the addition of knowledge and experience with similar cases.

Challenges

The ECMT doctor, with no plenty of emergency room experience but no RMS experience, feels that the pressure on the doctor is very high to make a proper diagnosis. His main concerns were faulty measurements from the captain or measurements which were taken with tunnel vision where the captain already had a diagnosis in mind. The RMS doctor did not seem to feel so much pressure as the ECMT doctor suggests. For the part, because he states, he does not feel worried how treatment goes. He keeps his responsibilities small, which is creating a probability diagnosis and giving advice. The first most important question for him is: is it life threatening or not?. They call this triage, to quickly find the problem and see if it is life-threatening. For stitching for example, he said: "you can make a beautiful stitch or not so beautiful, but the wound will heal". The wound might not heal as fast and not as clean, but it will heal. As long as they bring the wound edges closer together, dr Van der Leer believes it is a big step forward to limit infection and speed up recovery.

For the RMS doctor, the biggest challenge is language. He states that sometimes he has minimal information form the captain to work with and struggles to get his questions answered because of language and sometimes a bad connection. This is primarily a challenge when the ship is in Dutch coastal area, and he has to decide for evacuation, and he cannot get more information.

The other challenge, not mentioned explicitly, but is apparent from some of his statements, is the need for it not to take too long. He is not always able to get a follow up from the captains but also does not always asks for one because it takes extra time. The conversations over the phone usually take about 10-15 minutes, but he prefers if they email. The email is immediately documented and gives him the chance to review it; these are both time savers. Sometimes he asks one or two questions if the captain has no preparation on the patient information he will ask him to get the information and email him. It seems that the biggest challenge is not the language but getting all the necessary data. The data he is looking for is all on the evaluation form; he explains that if the captains have prepared this than the help is most straightforward to give. In training, they get taught to use these forms when they work with the actor and practice the communication with the RMS, but they do not always do this. They will say: "Jan has a sore throat and we want to give antibiotics and need the green light from the RMS". Questions like these are the most frustrating because he needs much more info before he can proceed by giving this advice. For the RMS doctor the information on the evaluation form is enough, he says he usually asks questions from the form for follow up.

In emergency care the doctor is usually looking for a first impression, this can already tell enough(Appendix B). For this a picture can often already be enough. The RMS doctor also like a picture, this helps him get a better overview of the situation and for example, give markers where to stitch a wound.

Potential value AR

The RMS doctor believes more contact between the doctor and captain will most likely improve the care. However, the time remains a challenge; it has to work with his work schedule the Dutch RMS is not set-up like for example the Italian where there are always full-time doctors. The details of the app were not discussed with RMS doctor as the company preferred the development internally. With the ECMT doctor, the potential of AR was discussed more in depth. He believes the most significant addition in the judge and stabilises phase is to help and find the treat what kills first. For the treatment phase, it is more like the captains pointed out in the test, the feeling of support and real guidance in performing skills. The ECMT doctor suggested thinking about various levels of acuteness in the scenarios. This is also the case in the current RMS services, at least in the request number the captain uses for contact. They have three numbers they can contact which will give the doctor an indication of the urgency. The levels he suggested
:
- Acute situation
    - Acute Do first
    - Acute Need help
- Semi-acute
    - Need help getting the story complete
- Non-acute but in need of support

The levels were considered and used to analyse different journeys which will are evaluated in the next chapter. Another valuable potential of the AR service is seeing a live response of the patient to the treatment which is especially valuable when performing an abdominal check.

The RMS doctor's focus is on probability diagnosis, and his first action is to see if it requires evacuation. To do this, the doctor often has to work with limited information. There is no first impression, and the captain is not always prepared which puts pressure on the doctor's schedule who is doing this next to his job. The doctor is in definite need of complete data but keeps a distance from the captain in his support.

First Needs

- First impression
- Response to treatment(abdominal treatment)
- Not take too much time
- Useful data on the patient, like the form(RMS)

08 Medical Care scenario

During the training, the Captains go through classes which involve theory and practice. They practice skills like setting an IV and stitching multiple times in class. Another important part is practising the theory on an actor who is acting out various symptoms, and they have to handle the situation as taught in class.

To build an understanding of the context the training was observed and participated in to built an understanding of the captains perspective. The training allowed to get a good understanding of the different medical procedures which the captain can be involved. At the same time, it provided an opportunity to talk with the captains about their onboard experiences. The medical experience of the participants was unfortunately limited, but their descriptions of the situation on board and observing the training pro¬cedures was very valuable.

Based on the observations the conclusion can be drawn that there are different levels of urgency for medical situations on board. The steps of dealing with the situation are very similar but the time and actions in the steps seem to differ slightly for every scenario. First, it is valuable to make a good representation of the general steps in the scenarios which the participants are taught during training. From there X scenarios are explored depending on the level of severity of the medical situation. The analysis of the steps of the treatment is based on the STCW Medical First Aid & Medical Care book co-authored by Dr W. Boon the owner of the training centre for which this book is used as a guide during training and handed to the students to take home.

General scenario

There is a general scenario of steps through which the trainee learns to go through during the training which is also in the book as a flowchart(Figure 16) and listed below.

Steps in the scenario

1. SAFE
2. ABCDE, Evaluate the general condition of the patient
3. AMPLE, Targeted research into the condition of the patient
4. Document the findings, using the evaluation form and hand over to the RMD
5. Discuss the findings with the RMD and agree on the treatment

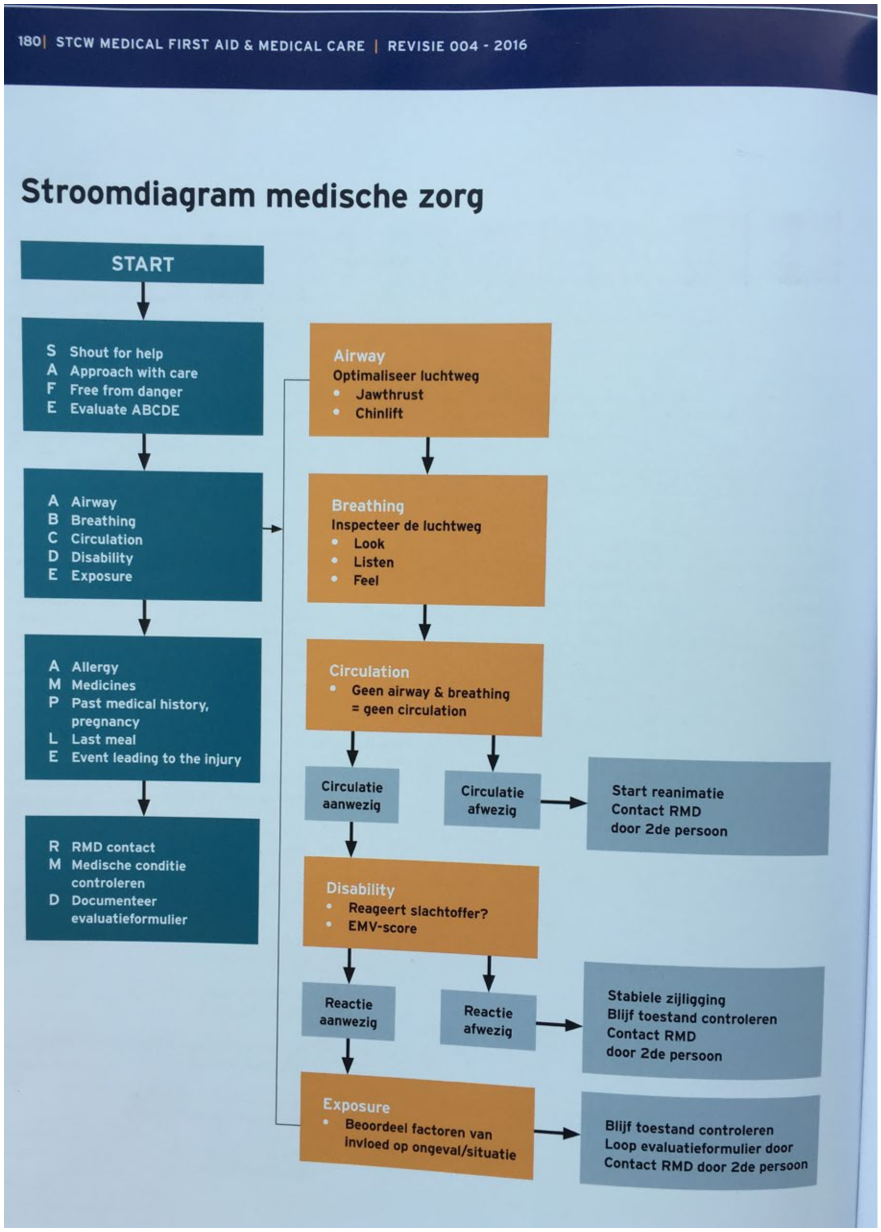


Figure 16: Flow chart medical care from trainings book

8.1 Acute and non-acute

Acute and non-acute scenarios were evaluated to see if they have different journeys. The scenarios considered were: Heart attack(Acute), Accident with burn wounds and smoke inhalation(Semi-acute) and food poisoning(non-acute)(Appendix F). The reason of choice of these scenarios is because these are common scenarios on board.

Based on the observations the expectation was that the that there would be a large discrepancy between the attacking of the situation for various levels of severeness. However, as could be expected, the steps are built in such a way that the method is ready to cope with any scenario. Rather than creating multiple journeys, the observations were integrated into a more complete and better overview which shows more clearly the flow of the steps in Figure 17. The most significant addition, apart from the different design, is the step that they always do circulation check first by asking for a response and follow this up with a quick ABC before going to the more elaborate and ABCDE where the data is taken and logged.

Roughly three phases can be distilled from the steps the captain has to take during a medical incident on board which have been represented in the flowchart in figure 17. The first step in treating patients is to make a quick analysis of the situation and immediately go through the C and if necessary D to see if there are any acute situations from where they move to stabilise the patient for more evaluation.

From the observations, it was taken that in a non-acute situation the captains go through a lot of the research steps before calling the RMD. They not only do the evaluation form but also start on the more extensive in-depth questioning to get as much information as possible. This is not entirely in line with what the book says or what the diagram advises. There an ABCDE and evaluation form suffices. However, is some cases it might be necessary to act in the form of an oxygen mask and a drip feed, neither which can damage the patient but both can save it. For this reason, it is valuable to be with multiple people to do actions, research and calls the RMD. The call to the RMD has been included in the flowchart and depends on the status of the patient. In figure 17 markers are put where 2-way-AR could add value. In the parts below the potential value is explained in more detail.

Judge and Stabilise

During the first phase after the incident, the captain has to go through the SAFE steps and do a quick evaluation usually start by looking for a response. During these moments what could be the value of the AR application?:

- Get a 2nd opinion of the first observations before the approach
- Get a 2nd opinion on the C and potentially AB and DE
- If necessary guide the captain through the CPR

For the second part of stabilising the patient, it is all about making sure the patient is not in any shock or need of acute care and the first more detailed diagnosis can be made with the first actions to keep the patient stable and ready for further treatment. The goal of this phase is to act with decisiveness and precision without doing extra damage.

Analyse and Diagnose

In any critical situation, a live connection should be set-up as soon as possible. Make sure to get the first info on ABCDE and make a connection to get the 2nd judgement. Also particular important with situation-specific accidents to get a second opinion before taking action.
With the AR app, the doctor can prioritise the information the captain gathers and the actions they take in a distant non-stressful environment. This way the captain saves valuable time on considering his steps or gathering information / taking action which is not value adding.
The second moment the AR app is valuable is when the patient is stable, and the patient is reviewed in depth, and the doctor can guide the captain through the steps helping with prioritising while also getting live feedback himself. The value-added part is a more concise analysis of the patient through the guidance of the doctor and a better analysis of the situation.

Treatment and Aftercare

For the treatment phase the value of the app is in creating confidence in the procedures. This is the part where the captain might have to take some action which are outside his comfort zone

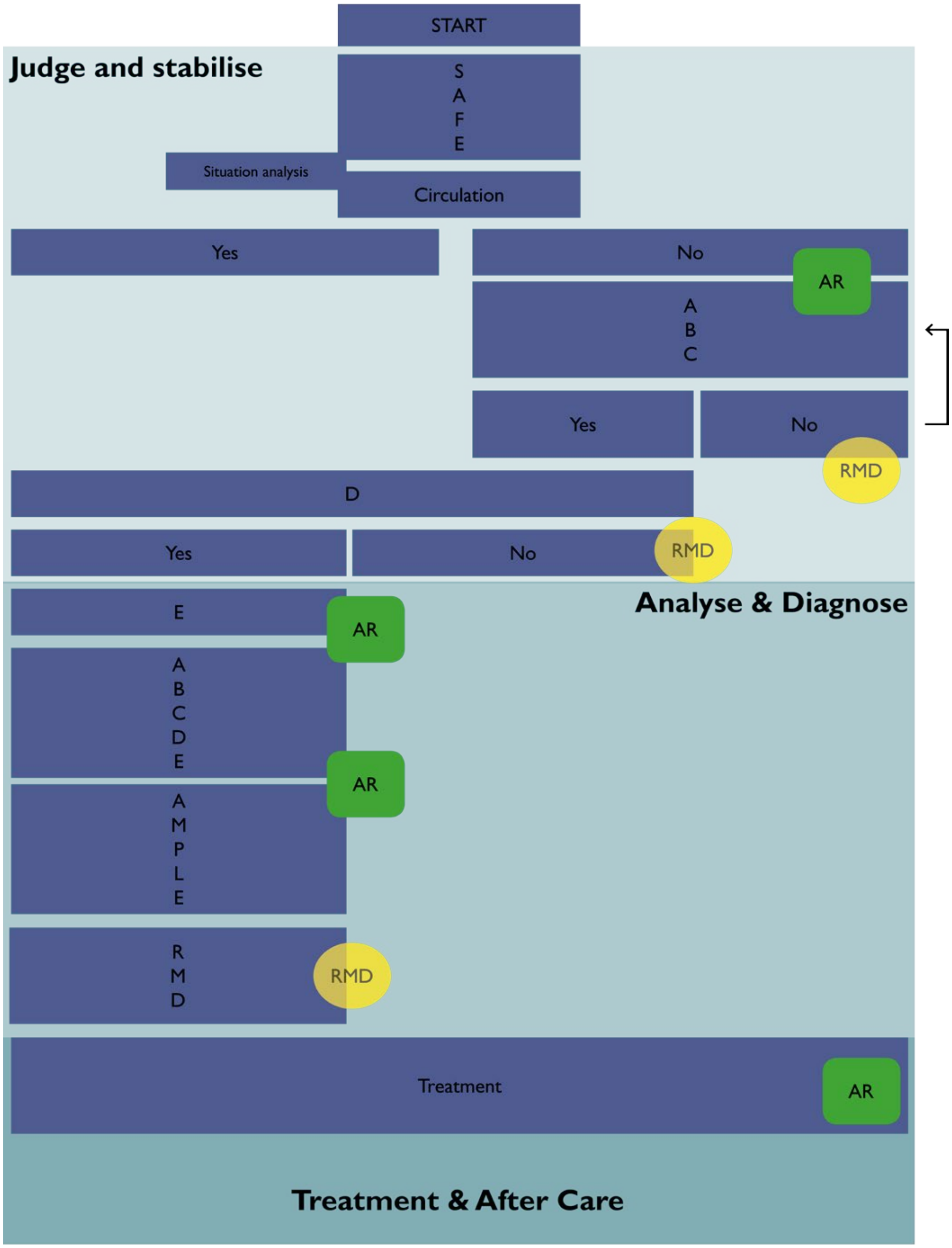


Figure 17: Flowchart from based on observations from training and reviewing the book

and he does not feel confident he has the skills to treat the patient, like for example stitching.
Example options
- Critical position of the patient
  - o Underneath a container with his leg
- Unconscious on the deck, nothing around him
- Broken leg bottom of stairs

Conclusions

1. There are different levels of acuteness An important part of the training is learning the ability to identify acute and handle them
2. Critical in the scenario is going through the evaluation form which has the ABCDE sequence and all the medical data required for the communication with the RMS
   a. Before RMA it is all about stabilising and getting out of life danger
   b. After RMA they take more action
3. It is likely that there are multiple people around to help with the care
   a. Care can be on the hospital, but most likely the incident is somewhere else on board
4. There seems to be no clear communication protocol with the RMS

03
DESIGN CHALLENGE

09 Customer Journey

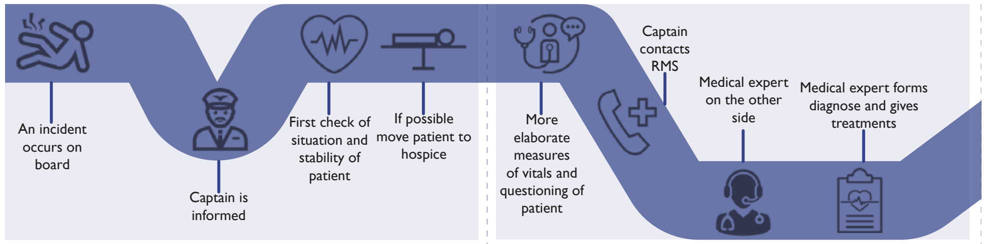
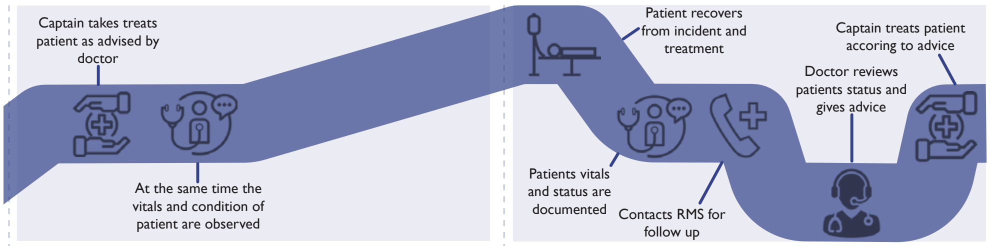
		JUDGE & STABILISE	ANALYSE & DIAGNOSE
NARRATIVE	The process		
	The story	There is an incident on board which requires medical attention. Immediate action is taken to judge the status of the patient, stabilise him and prepare for the next step.	In the analyse and diagnose phase the patient is researched in more detail, additional information is gathered on the patient to communicate to the doctor to help him build a good diagnose
	Time spent	5 min	30 m
CAPTAIN	Actions Taken	INCIDENT / SAFE / ABCD	ABCD / AMPLE / CONTACT RMD
	Thoughts and concerns	1. Feels unease when he is informed about the incident 2. Is likely for him to see a situation he has never experienced before 3. Does nog know exactly the first steps of actions but knows where to find the information	1. Is happy to talk with in expert about the situation ans share some of the responsibility 2. Feels not confident he can complete the actions the doctor has given him 3. Questions if he has taken all the right measurements
	Information they are looking for	1. What happened during the incident 2. Any major complications which have to be taken care of immediatley 3. Confidence and positive feeling	1. Looking for more certainty in his analyses on the paitient 2. Is wondering if there is anything major with the patient which he is missing 3. The first actions he has to take 4. Will the patient make it?
	Emotions		
DOCTOR	Actions Taken		FORM DIAGNOSIS
	Thoughts and concerns		1. Feels he has limited information to make a decision 2. Questions the accuracy of the captain 3. Concerned about tunnel vision 4. Feels pressure to make the right decision
	Information they are looking for	1. First impression of the patient 2. Treat what kills first	1. Live response to the analyses done by the captain 2. An indication of the level and quality of the captains measurements
	Emotions		
PATIENT	Actions Taken	INFORM	INFORM
	Thoughts and concerns	1. Is scared 2. Hopes he gets the best care possible	1. Questions the ability of the captain
	Information they are looking for	1. Will I be alright?	1. Certainty in the diagnosis
	Emotions		

Figure 18: Customer journey based on the insights from tests, observations, intervies and analyses

MedAssist.online™

TREATMENT	AFTER-CARE



TREATMENT	AFTER-CARE
Apart from the first treatment actions in the Judge and stabilise phase, this is the phase during which the next steps of treatment are taken based on the diagnose and advice	During the after-care the patient is reviewed on his recovery by again measuring his vitals and questiioning him and discussing these results with a doctor.
60 min	**30 min**

PREPARE | TREATMENT | GATHER VITALS | CONSULT RMD

1. Feels out of his depth and insecure to provide the skills nessecary to treat the patient
2. Feels left alone from the previous step

1. Wonders if he did a good job
2. Hopes the patient will get better

1. Guidance and confirmation during the practicing of the skills
2. Warnings if the status of the patient changes during treatment

1. Confirmation and feedback about the treatment
2. Information on how to evaluate the patient

GIVE ACTIONS | REVIEW | NEXT STEPS

1. Wonders if he gave the right advice
2. Hopes the captain can follow the advice he gave

1. Is the patients status stable or improving?

1. Live response of the patient to the treatment
2. Feedback if the captain is doing the treatment right

1. Know the status of the patient
2. The response to the treatment
3. Any other complications which might have arisen

INFORM | RECOVER

1. Wonders if the captain can fulfil the treatment

1. Will I have any after effects?

1. Confidence that the captain is able to treat him well

1. The next steps in his treatment
2. The duration of recovery
3. Any future side-effects

The insights from the interview, test and observations were summarized on one big customer journey(Figure 18). Based on the analysis of the scenarios the narrative was split into four phases with a visual representation and description what takes place in this phase. The insights from the interviews were put into 'thoughts & concerns', 'information they are looking for' and 'emotions'. The customer journey gives way to analyse what is working well in the current scenario and what is not too later in the process address these opportunities with the service design.

9.1 Take aways customer journey

The customer journey is a very complte summary of insights from research and provides a strong bases to identify the strong and weak parts in te current journey. In figure 19 the strong and weak parts have been identified and numbered, the isnights are described elaborately below.

Going well in the current scenario

1. The moment of communication with the doctor is very valuable for the captain. This is the moment he gets the chance to share some of the responsibility and expert input. Up to this point, he has done all his actions based on his training.

Goes well if..

1. The first actions by the captain are not by definition good or bad. If the captain is well trained and can handle the pressure and feels confident, he will be able to handle the situation. Also if the scenario is not very acute than the pressure is lower, and there is more time to questions his steps and review the handbook or skills app. If the captain does not know what to do the initial stabilising of the patient might be rough.
2. In the aftercare, the captain and doctor will be in touch about the recovery of the patient to discuss any follow-up steps if necessary. However, the quality of this discussion entirely depends on the accuracy of the captain's measurements and the patient's responses to the questions. Most likely the patient, at this stage, is in better shape so can give useful information to the captain. This is potentially the first moment the doctor can ask more detailed questions and maybe talk to the patient directly.

Room for improvement

1. In the initial confrontation with the incident and patient, the captain might feel out of his depth immediately. There is no support for him to master the situation or to give him handles on what to do and what to do first. There is an opportunity to support the captain in the steps to handle the situation and provide additional support if necessary.
2. Doctors always search for the ' treat what kills first' in the emergency room. This follows a similar step-by-step process as the captains get taught in class but of course much faster and more detailed. The experience of the doctor allows him to exclude and include scenarios that he wants to check in more detail. In the current scenario, the doctor does not have the opportunity to judge the first situation since the captain is first handling it. This is a missed opportunity because it can help the doctor form a better diagnosis as well as point out specifics the captain has to look out for.
3. In the entire scenario, there is very little attention to the patient. Based on the observations during the training situations, there is minimal role for the patient, apart from being the focal point of attention and answering the questions from the captain. During this whole time, the crew member is not feeling well and needs to have faith the situation will be handled well. There is very little comforting or reassuring done, and the captain has the contact with the expert, not the patient like in a normal doctor-patient relationship. For the wellbeing of the patient and the quality of the care, it could be valuable to make the patient feel good and involve him more in the process, also directly with the doctor.
4. In the analyse and diagnose phase the doctor faces the challenge to make a decision based on the information the captain provides him. The doctor has the opportunity to maybe ask some additional questions from the captain but has to trust the captain that the information he provides is collected the right way and unbiased. For this phase, it could help the doctor build some trust if he can see the process of gathering the information on the patient and direct the captain in his research and see the response of the patient to for example an abdominal check.

5. In the treatment phase, there is the chance the captain has to perform skills he learned in training
   a. During the treatment, the captain needs to take care of the patient, so they can recover in the best way. However, the captain is undertrained and under pressure to take the best care of his crew member. He does not feel confident that he can do it and is lacking support. This is where the project was initially started to use 2-way AR to allow the doctor to support the captain in his actions. He is looking for confirmation and correction in the treatment process which gives him more confidence and the feeling of shared responsibility.
   b. After his advice, the doctor wants to know if the captain can follow up his advice and see the response of the patient to the treatment. Currently, he gives the advice and leaves the captain to it. There is an opportunity to keep the doctor more involved to give guidance to the captain and interfere if for example, the status of the patient gets significantly worse.

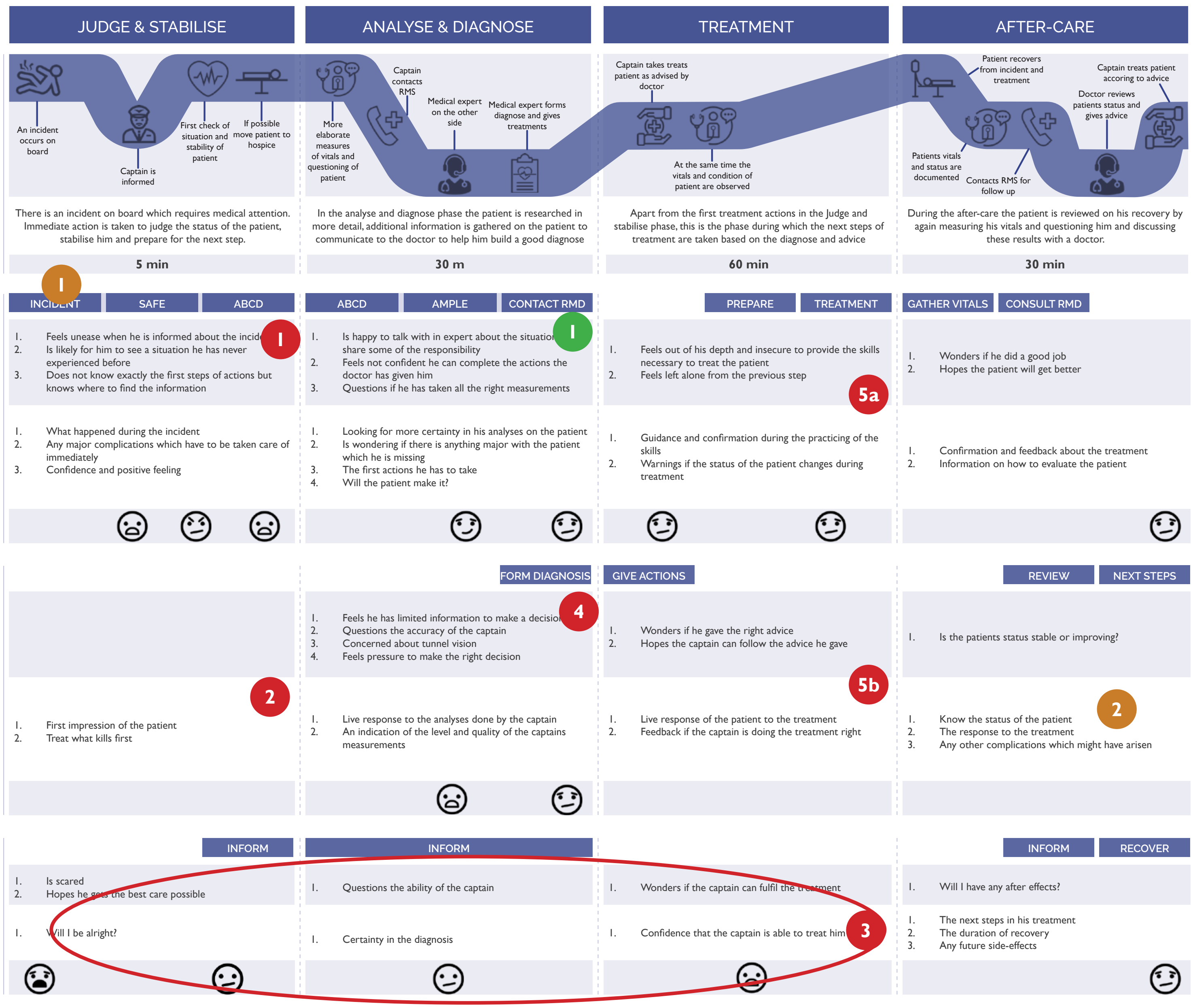


Figure 9: Customer journey with indications what are strong and weak points in the journey

9.2 Gaps in curernt scenario

The points addressed in the previous section give a heightened understanding of the journey and make room to see opportunities. Looking at the gaps that there are between the different actors helps to understand the value the service can bring rather than focussing on function.

Working from left to right through the gaps in Figure 20, after the initial medical incident, the captain will get an overview of the situation and first impression of the patient which the doctor has not so there is an information gap there. In assessing the situation and making the first steps to stabilising the patient, there is a clear experience gap between the doctor and captain, and there is no way for the doctor to add his expertise. This is the same in the analyse and diagnose phase where the captain has to get all the info but might lack the skill and experience to do this. Overall there is a complete lack of communication between the doctor and patient, which is not indicated as necessary but the doctor actually wants it to be this way. The doctor talks with the captain, not the patient. The last gap is the clear gap in skills to treat the patient with an appropriate level of skill.

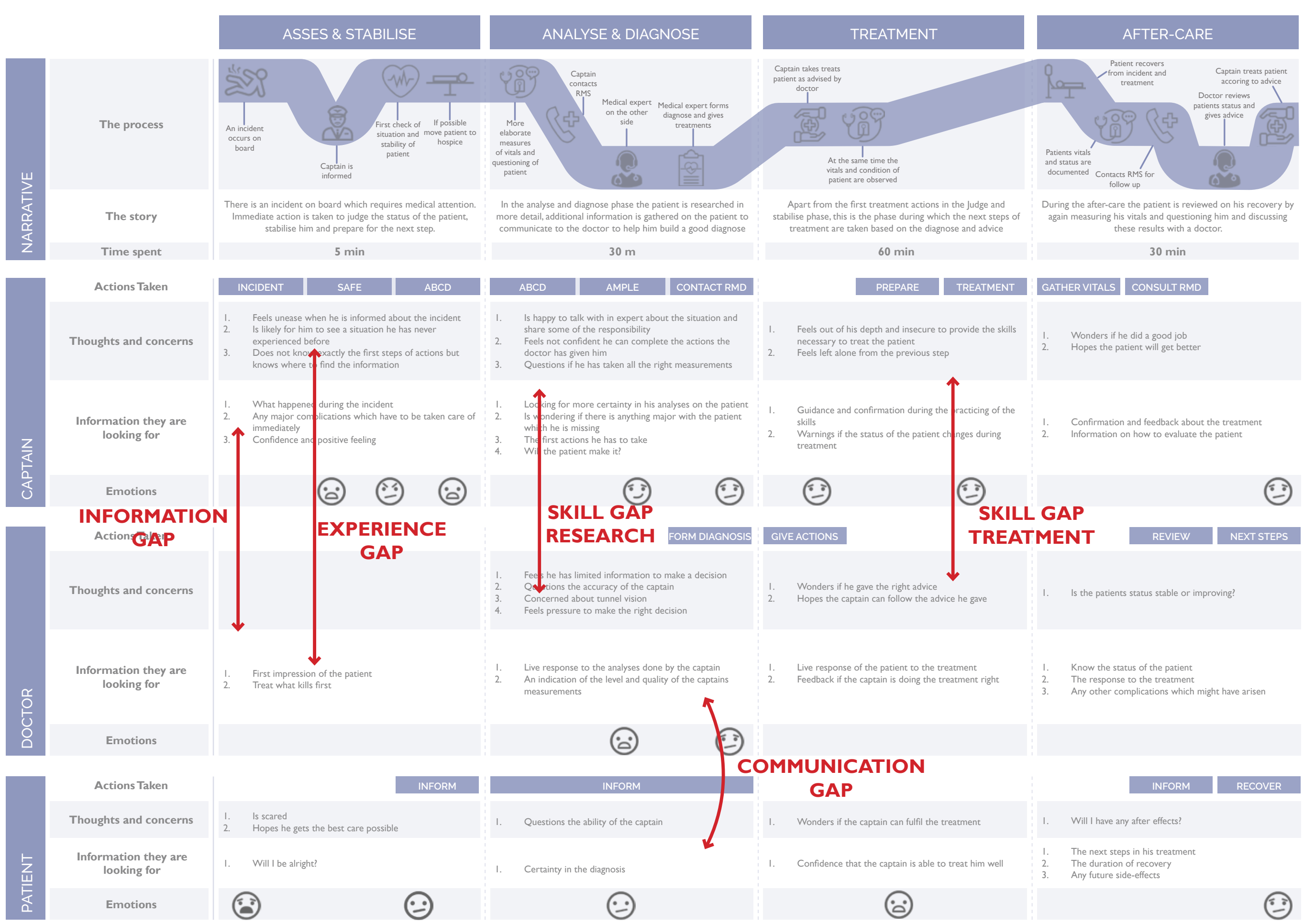


Figure 20: Customer journey with gaps

10 Design Challenge

10.1 Design Challenge

Based on the insights from the research it is clear that there is a need for more support for the captain. In figure 21, it has been visualised how the service is envisioned to achieve this. The service could allow for an increased number of interactions with the doctor. The increased interactions will help build the confidence and at the same time allow for information sharing between the two parties. A good example of this information sharing could be the medical data, which is sent before the doctor and captain go into a live connection. This way the service supports the doctor by triggering the captain to get all the data while at the same time giving the captain the feeling that the is not alone.

The most important interaction is in the treatment phase where the 2-way-AR technology is most valuable to allow the doctor to give precise instructions to the captain. In figure 22 the set-up as imagined up to this point for the project is visualised. Both sides use a tablet and a tablet stand which is highly adjustable to work with the product. During the field research, some initial testing was already done with the app and set-up to get insight into the captains thinking and response on the app. During these tests, it was already clear that the envisioned set-up with the app being as it is does not necessarily mean that the 2-way-AR's potential is fully met. The hands are big in the screen, it is hard to communicate, and the iPad is often in an awkward position. So the design challenge for the project has been to research a set-up which will make it possible to use 2-way-AR as it was intended: a tool for the doctor to give precise instructions to the captain during medical care. At the same time the service is developed so that is not just functional but also helps with the medical journey and feeling of support(Figure 21).

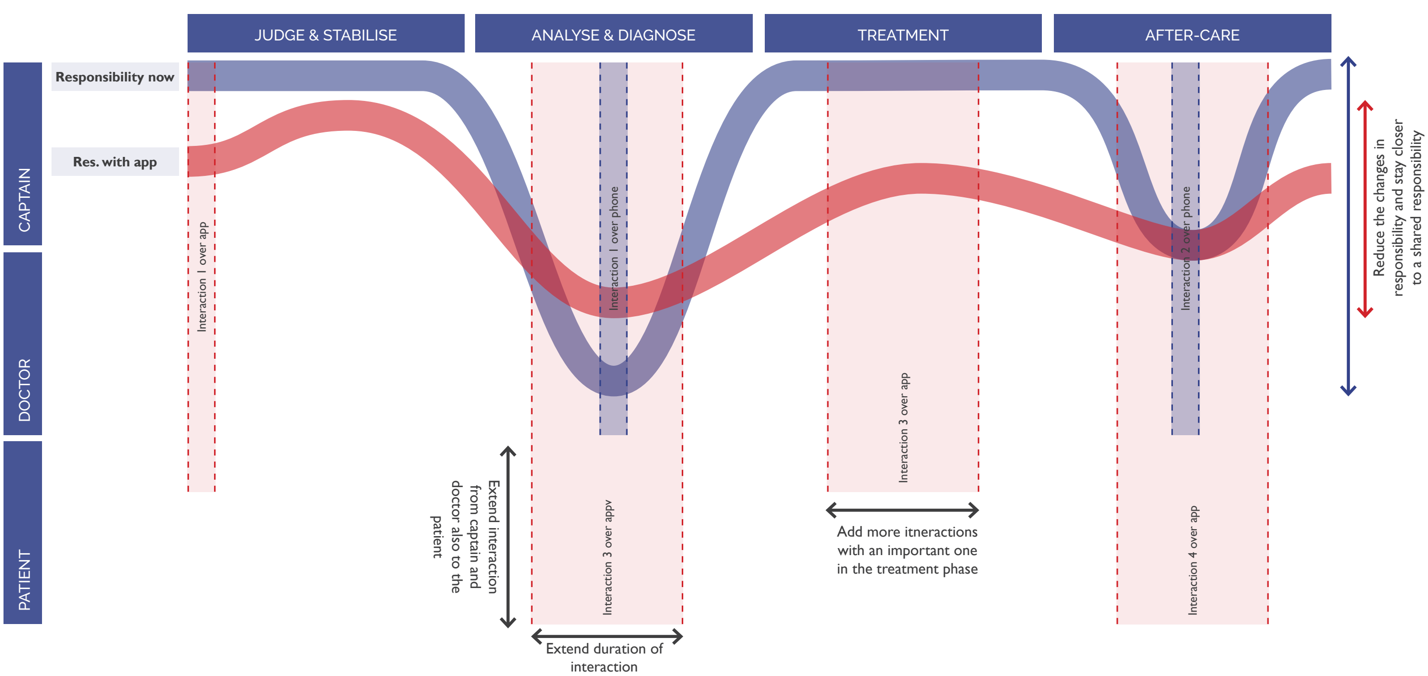


Figure 21: Potential of 2-way-AR service

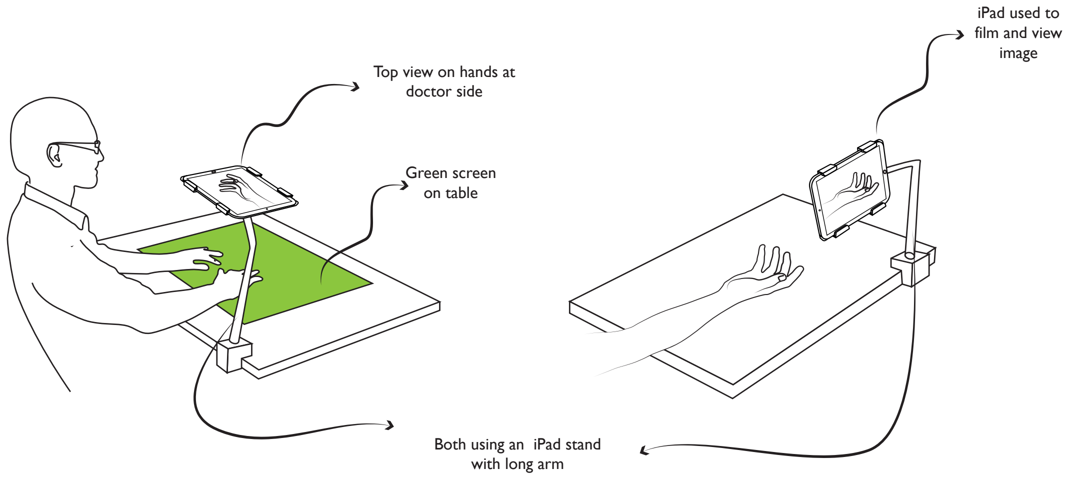


Figure 22: Envisioned set-up by MedAssist.online

1. The focus is on finding a set-up which makes it easier to use the 2-way-AR functionality
2. Confidence is created through the communication with instructions, the captains feel this improvement
3. The potential of 2-way-AR to give detailed instructions is not being met to this point
4. Three parts have been identified with parameters to be defined with prototypes and tests

10.2 Medical scenarios

To move forward with the development of truly unlocking the potential of 2-way-Ar it is important to address the medical situations the app could be used for. In the analysis it was defined that the main potential of the contribution of AR is in the skills phase. From the skills app developed by MedAssist.online a long list of skills can be extracted which are most commonly needed on board. Talking with Dr. Boon, the owner, and reviewing the skills app and observations three medical scenarios were selected to keep in mind when working towards solutions. This is especially important because of the detail of the instructions and the optimal camera positions.

The first scenario is a cut in the arm or having to set an IV. The focus is the arm where a view of a large part of the arm is needed with some close ups when reviewing the wound or needle.

he second scenario was a suggestion from Dr. Boon. In this scenario there is a splinter in the eye of the patient. This is a scenario which they do not learn in training and requires some specific skill. He suggested that it is probably not something they would do at the moment but with the support of AR could do.

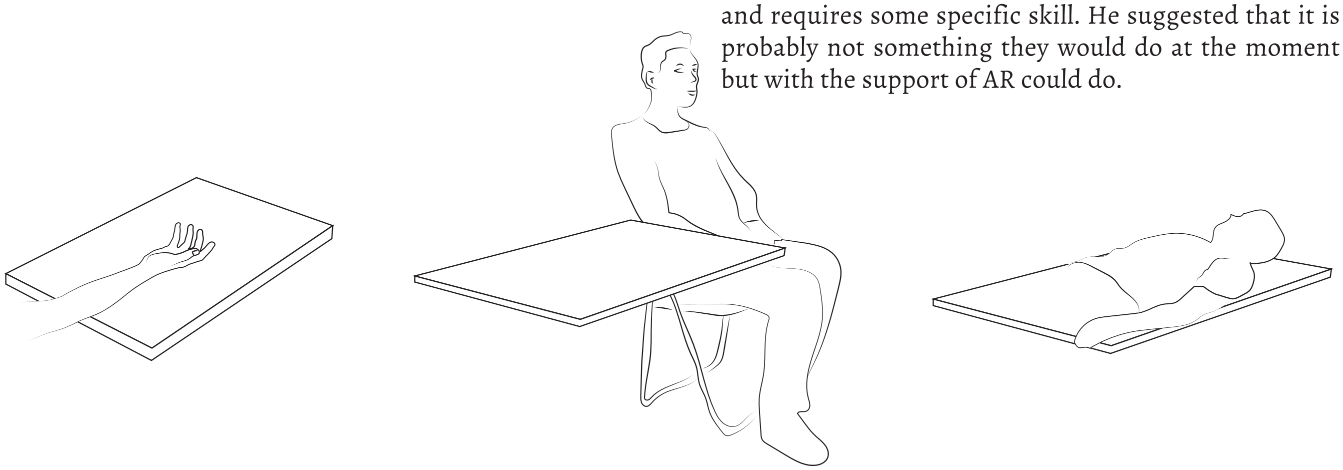


Figure 23: Positions of the patient for three medical scenarios

04
Conceptualization

11 Testing with 2-way-AR

11.1 Small test with 2-way-AR

From the analysis the design challenge was specified and focussed on making the 2-way-AR interaction work. Parallel to this exploratory research with 2-way-AR the technology itself and the application were developing.

The first test performed with 2-way-AR was done with a barebone version of the AR application. For the test protocol and results please refer to appendix E. In the test the two captains were asked to move shapes in different colours(Figure 24). The goal of the test was to see how well the captains were interpret the instructions given by a remote expert. The instructions were either given by audio, by pointing using the AR or both to get a feel for the value of the AR functionality in the application.

From the test can be concluded it is clear that the value of the AR functionality is immediately apparent to the captains. Both captains see the value in live support. The voice of the expert has a calming effect and creates trust and one captain even points out that it feels very similar to the training situation where there is always someone looking over your shoulder, this exactly the feeling MedAssist.online is going for with the application. The application can take away the threshold to act by reducing insecurity. There was even the suggestion to expand the feeling of trust by adding the face of the doctor. In terms of performance of the AR functionality, just working with audio performs better than just working with the hands.

One interesting side note was pointed out by the trainer who was present at the test that there might be a need for some form of communication protocol. The communication protocol could, according to him, overcome both sides talking at the same time and coping with connection loss.
The test proved the potential of AR in a live connection and the goal of the application was clear, even though the test did not use a medical scenario.

11.2 First big test 2-way-AR

The test discussed above was, as mentioned, performed with a semi-functioning version of the application. For this reason the test was focussed on testing the technical performance and trying to get a first response of the captains on its potential value. The test did not test the AR functionality very thoroughly so a more elaborate test was performed with a medical scenario and comparing a live video connection with the 2-way-AR functionality.

Figure 24: Captain moving shapes with AR instructions

Goal
To see test the added value of the AR functionality the test was set-up to compare the 2-way-AR application with a facetime connection(Appendix E). To test the performance of the application the participants were asked to build 2 Lego structures using the instructions of an expert(Figures 25 & 26). In addition to this comparative test the captains were asked to perform a medical scenario, an intramuscular injection, with directions from an expert on the other side to also get their insights on the value of AR.

In figure 26 the captain can be seen seated with the tablet ready to receive instructions from the expert to construct the Lego's lying ion front of him. In Figure 27 the medical set-up can be seen. For this set-up a different tablet stand was used to allow some more freedom and for the captain to be able to film the whole work area while working.

Conclusions
For the lego tests there is value in the hands for when audio drops. Due to the loss of audio both captains felt slightly less calm and effective on the scales(Appendix E). For a large part this can be attributed to the loss of audio. Though the hands add a lot of clarity they are not always 100% clear and the captain still relies on the audio. Similar to the test with the coloured shapes the captains see the value of the hands as it is an extra confirmation which can give comfort in a situation of stress.

The issue with the tablet position is that it is hard to see the instructions while working. This is especially troublesome

in the medical scenario where the work area is fairly big and the stand used has to stand in front of the table. One captain changed the tablet position so the doctor could see everything, the other kept it in one position and was working around it. The tablet was in the way of his actions and hardly ever gave a good view for the doctor, much of the actions were not viewed by the captain.
Both test show that just having an expert seeing what you are doing is already of tremendous value. An interesting observation was that one captain failed to correct himself and did not take out all of the air from the syringe. When asked after the scenario he said he saw it but did not consider taking it out. It seems that he was relying on the instructions very much.

Limitations test

There were a few limitations to this test. The first being that the captains had just received the training in intramuscular injections. Even though in a realistic scenario on board the captains have also received the training the intramuscular injection proved to be very easy and the captains did not really need any instructions. The other limitation which influenced the results of the test are the audio issues of the application were strong which were partially solved by making the captain wear headphones(Figure X), but they still experienced a lot of loss influencing the results of the test.

Input for design

One of the captains very cleverly pointed out that he would rather have the tablet with the instructions behind his working area, as if you are typing on a computer with the screen behind it. For the medical scenario the set-up with the tablet stand is not flexible enough to work with. The second input or challenge are the hands in the screen, the hands of the captain blocking the view of the captain and the hands of the captain and the doctors hands for instructions blocking a large part of the screen. The last observations was that the hands of the doctor often covered a large part of the screen and the doctor has only limted control over the size.

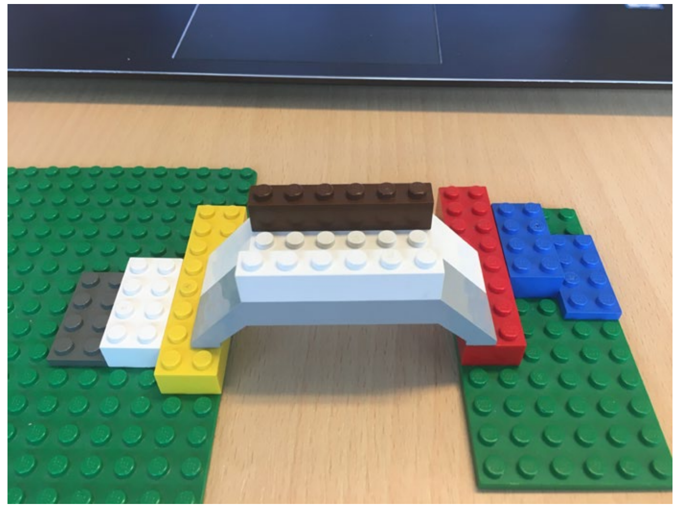


Figure 25: One version of lego structure test

Figure 26: Building lego's with AR instructions

Figure 27: Medical scenario test with tablet stand

12 Captain

12.1 Stitching test

The first step taken to move towards designs on the captain side was to confirm some of the results found in previous tests — especially the test where Legos structures were built with a facetime connection compared to the AR application and performing a medical skill with the AR application. After the first tests with two-way-AR, the realisation came that the medical procedure used for the test(intramuscular injection) was not complicated enough to test the value of 2-way-AR. It was also found that the iPad stand was not flexible enough to work with. For this test new stands will be used and evaluated. In the interview the doctor from the Radio Medical Services(RMS) explained that he sometimes draws lines and arrows on images of wounds to help with the stitching process for more complex wounds. For this test, such a scenario was created with the complex wound, not a straight line, in a piece of pork belly which was photographed and instructions were drawn on top with a description(Figure 30 & 31). For the other wound, the instructions were provided through the AR application. The test was performed with two captains who were in training(Appendix K).

Interestingly enough, but not a new result, the responses to the 2-way-AR application are mixed(Appendix L). One captain prefers the AR application because it allowed for discussion and correction. The other captain felt the app was limited as he would instead work on his own pace. Similar to the test with the shapes it was pointed out that a communication protocol might be valuable. It can be hard to realise when the captain is looking at the screen to follow the instructions. The hands remain rough to give and receive the instructions with, especially with such a close up the scenario as the wound. After the test, the captains were also asked if they minded being watched while performing the skills they even forgot about it sometimes.

The reason that they forgot the doctor sometimes could be partially attributed to the limitation of the test. The complex wound scenario seems more difficult, but after evaluating the wound, it turns out the captains needed only minimal instructions during the stitching. The communication, again, seemed to be influenced heavily by the audio loss of the application.

12.2 Captain camera set-up

Two test performed with the AR application and captains involved both showed struggles with the iPad position and camera angle for the doctor.

One of the critical parameters with AR communication is the understanding of the remote party, in this project the doctor. To achieve a better shared understanding and allow for the tablet to be placed behind the work area the camera was disconnected from the tablet. In figure 28 the three camera positions to place the camera in were suggested.

The most likely idea which comes to mind is to have a camera in a pair of glasses. This is a self-explanatory option because a lot of AR development is taking place with the use of HMD's which have a camera in them to film. One advantage is that it gives the recipient a similar view to the captain and at the same time any instructions given by the doctor are given on his perspective. The assumption is that the same view will make it easier for the doctor to understand the situation and give instructions as the captain will take the best perspective of the situation and the instructions are more accessible to implement if they are the same to his perspective.

To test the experience and performance of a different camera set-up for the captain, an endoscopic camera was taped to a pair of glasses to see the performance(Figure 29).

Figure 28: Possible positions of camera captain side

Figure 29: Camera connected to glasses for test

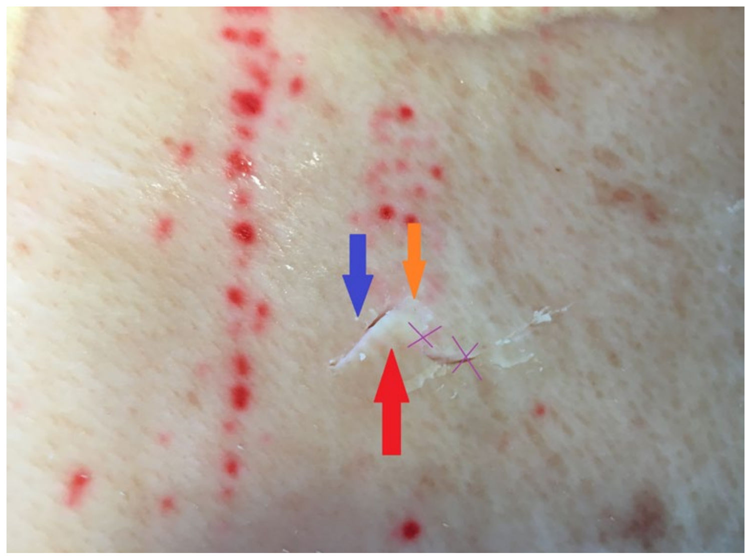


Figure 30: wound with arrows for instructions

Figure 31: Captain stitching with paper instructions

12.3 Test with new camera angle

As discussed above the focus of the test was on using a different camera angle on the captain side to see if this improves the understanding of either side and makes it easier to understand the guidelines. Also, this opens up the opportunity to position the iPad behind the patient to make it easier to work with, based on a suggestion from an earlier test. The position of the iPad has been an issue from the beginning, and the new stand has improved the workability but can still be in the way of the hands. To make the scenario more realistic, the working field will be simulated to be bigger than it needs to be so there is a need to work with the position of the camera.

For this test two colleagues were asked to take part, they did not have experience with the application yet. The reason for this choice was their availability over the captains and the time they could spend on the test. Similar to some of the previous test Lego structures were used again to make the test more standardised (Appendix M). Also for this test, videos were made for observations, the procedures were timed and interview questions for both parties and documented(Appendix N). The scenario was set-up so that they were not allowed to communicate to focus on the interaction.

Results

During the test, two important modifications were implemented which were not part of the original scenario. The first is that the participants, one being the doctor and the other the captain, were given a chance to practice. For a good two minutes, the doctor gave the captain some instructions, non-scripted, through the AR app without talking as they were going to experience in the test. The reason for this is to take away any bias between the first and second scenario due to learning how to communicate over AR.

The second modification was made during the first scenario and copied into the second. The first scenario using the tablet's cameras took so long I decided mid-test to stop it at 6 minutes. After this 6 minutes, I checked the progress they made and had them fill in a questionnaire. After filling in the questionnaire they were asked to continue with the scenario, but now they were allowed to also voice chat. I timed this part of the scenario as well to see differences between the first and second scenario potentially, and they were asked to fill in the same questions after this part to identify the influence on the experience. The test persons were also in the same room to overcome the audio issues from previous tests.

Captain

From the scales in figure 32, it is clear that for the captain the second scenario worked better. As soon as he got used to working with the glasses, he felt it was much easier to work with the tablet behind the work area. He felt he could give the doctor a better perspective. Though the tablet creates a more stable view, than the camera, the perspective could not be made optimal for building the Lego structure which made the doctor's instructions harder to implement.

Doctor

The scales in figure 33 show that the doctor feels the set-up without the glasses performs better. The open questions after the scenarios give more insights and give opposing results. The participant in the role of the doctor says he prefers the set-up with the camera in the glasses as this gives him a better perspective. There are good reasons for why the experience of the When the camera is connected to the glasses video feed on his screen is moving around. Even the slightest head movements create large movements on the screen, and it influences the quality giving him a pixelated image.

Take aways

- Camera position is not just for doctor important; it is also about the instructions the doctor can give with the perspective
- Tablet behind work is confirmed
- Camera disconnected from tablet work well but needs to be more stable
- The camera needs to be adjustable

	1. Totally disagree	2.	3.	4. Neutral	5.	6.	7. Totally agree
The information from the expert was easy to implement					X	X	
During the building I made very little mistakes				X			X
I felt very calm during the building						XX	
I had a lot of confidence during the building					X		X
The expert was able to support me enough to do the building				X		X	
I felt as if I was on my own during the treatment		X	X				
Overall the building went very smooth					X		X
I felt very accurate during the building				X			X

Figure 32: Results captain, green set-up tablet red set-up glasses

Tablet

1. Pro's
a. Stable view for both parties
2. Con's
a. Takes the effort to move around
b. Changing perspective for a doctor
c. Hard to position right so that it works for both the captain and doctor

Glasses

1. Pro's
a. Having the doctor see exactly see what the captain sees helps for him to understand and makes it easier to give proper instructions
b. Having the tablet in a fixed position and not need much alteration works well, also having it placed behind the work field
2. Con's
a. It is not possible to look at the screen and situation at the same time

	1. Totally disagree	2.	3.	4. Neutral	5.	6.	7. Totally agree
It was easy to give the instructions to the captain					X		X
It was easy to understand the captains progress					X		X
I felt very calm during giving the instructions					X		X
I felt confident in giving the instructions					X	X	
I felt we were doing the building together							XX
Overall the building went very smooth						X	X
I felt very accurate during the instructions				X		X	

Figure 33: Results doctor, green set-up tablet red set-up glasses

Figure 34: Particpants in test with different camera angles captain

13 Doctor

13.1 Limitations envisioned set-up

The main requirement for the doctor is control over size hands to give instructions to increase the level of accuracy in the instructions per scenario.

In the envisioned set-up in figure 22, the tablet points downward on the hands of the captain underneath which a green screen was placed. From the tests, it was concluded that the hands were exceptionally large in the screen.

The set-up was reviewed to see in more detail the size of the hands on screen. In figures 35 and 36 the hands of the doctor can be compared at 20cm and 40cm from the camera. At 20cm the hand easily covers half of the screen while at 40 cm the hand covers about 1/4th of the screen. The advantage of smaller hands on screen is that the level of detail in pointing can be much higher as well as that hands move much slower over the screen making it easier for the doctor to control them. Based on reviewing the images it was concluded that the hands are acceptable size from about 30 cm up to 50 cm so the set-up should facilitate this freedom.

In the envisioned set-up this is not possible since it will be impossible to see the screen at the same time. In figure 37 the author can be seen sitting behind the iPad which is lifted 30cm from the table. The author is 188cm tall however 30cm is about the maximum height of the tablet can be while being able to see the screen of the tablet comfortably. A new set-up was created which can be seen in Figure 38, where the iPad is facing forward rather than facing down. This eliminates the maximum height and should allow for the hands to be controlled more freely.

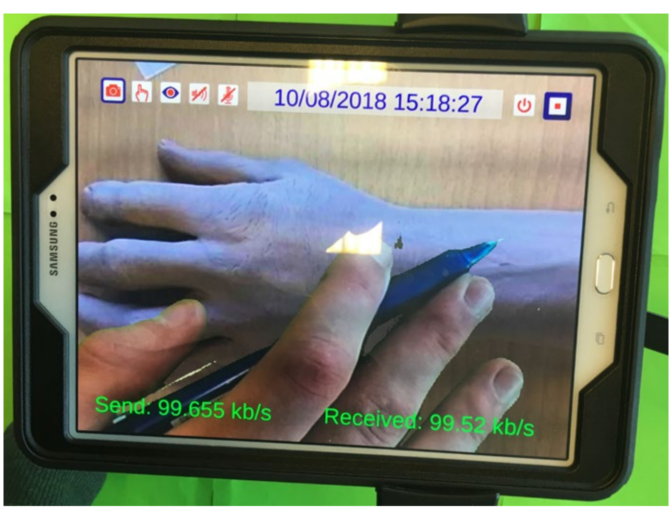


Figure 35: Hand size at 20 cm from camera

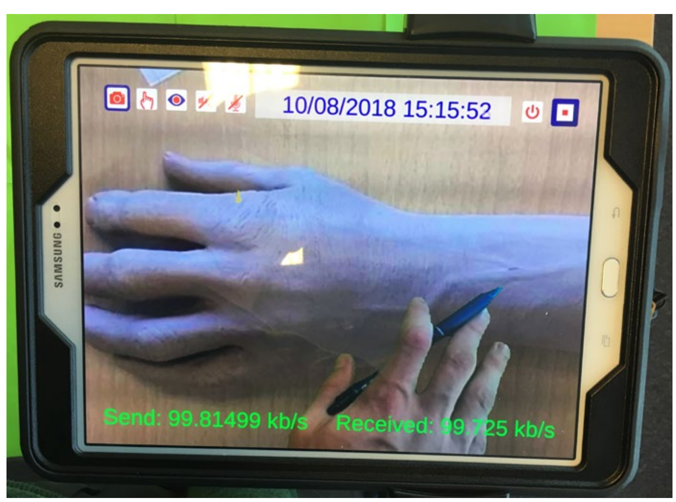


Figure 36: Hand size at 40 cm from tablet

Figure 37: Envisioned set-up at 30cm from table

Figure 38: New set-up to give more freedom to move hands away from camera

13.2 Variables in doctor set-up

In the new set up five variable has been defined which need to be specified of which an overview has been created in figure 41. The first variable, number 3 from figure 41, got its first definition from creating this new set-up at 50cm. Somewhere in the work area, the green screen needs to be at least 50cm away from the camera of the tablet. It was also assumed that the best position for the tablet is such that a 90-degree angle is made with the view of the doctor onto his own hands(Figure 43). To learn more about this set-up various positions were defined and explored to test(Appendix G) (Figure 42). In figure 42, there is also added the distance between the tablet and start of green screen. Based on DINED(2004) data it was concluded that the arm length is 720mm with an sd of 55mm(Figure 40). For this reason, the maximum reach was set at 70 cm. Since the depth of the green screen is 50 cm the distance from table edge to green screen edge is 20 cm.

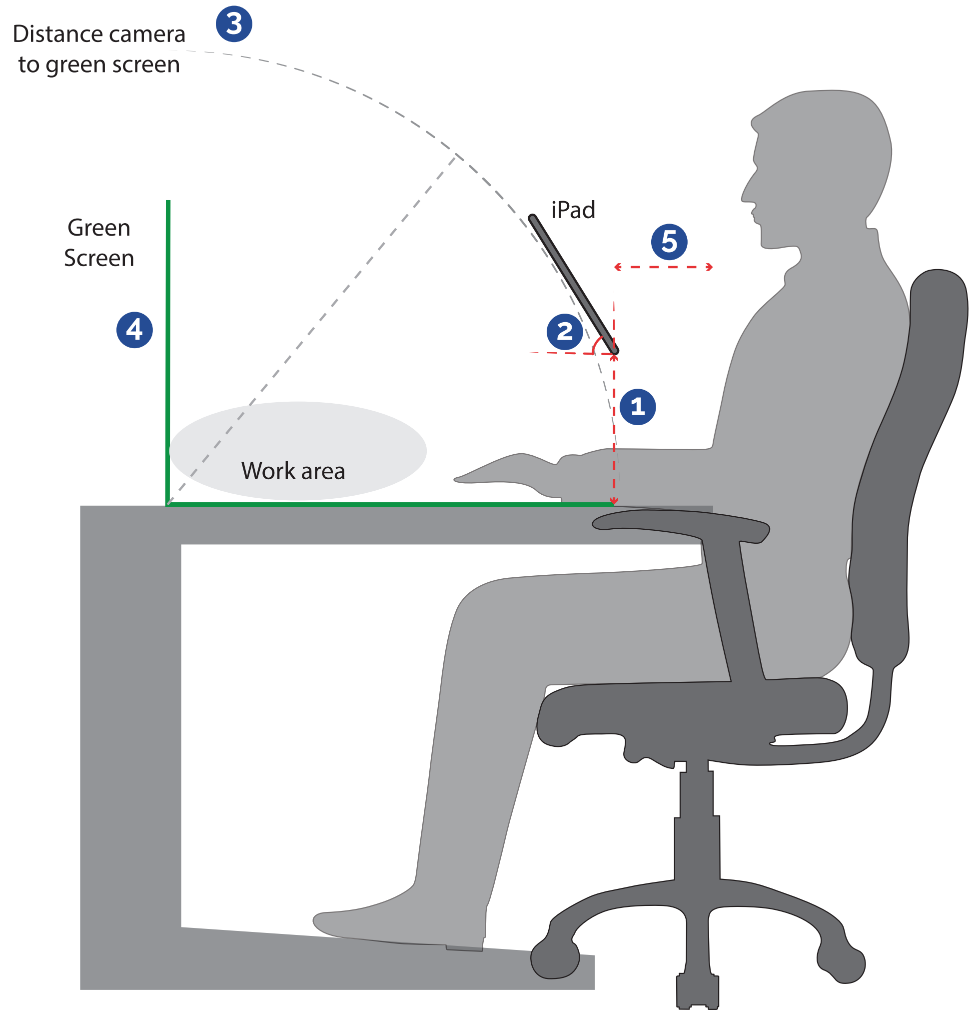
A test set-up which could accommodate for all of the tablet angles was built and is shown in figure 39. This set-up was decarded because it was very bulky and did not allow for the participant to move their hands free, so the set-up was improved.

The new test set-up, rather than being a full iPad stand with various positions, makes use of the tablet arm which is part of the envisioned set-up. For this test dies were laser cut with the right height angles which could be put against the tablet to put it in the right position

mean and sd		single m
populations	Dutch adults 20–60, mixed	
measures	mean	sd
Arm length (mm)	720	55

Figure 40: Results doctor, green set-up tablet red set-up glasses

Figure 39: Test set-up that is too bulky to test functionality



1. iPad height from table
2. iPad angle (measured from the table)
3. Distance from iPad to the green screen
4. Size green screen
5. Distance iPad to eyes --> distance iPad from the table edge

Figure 41: Parameters doctor set-up

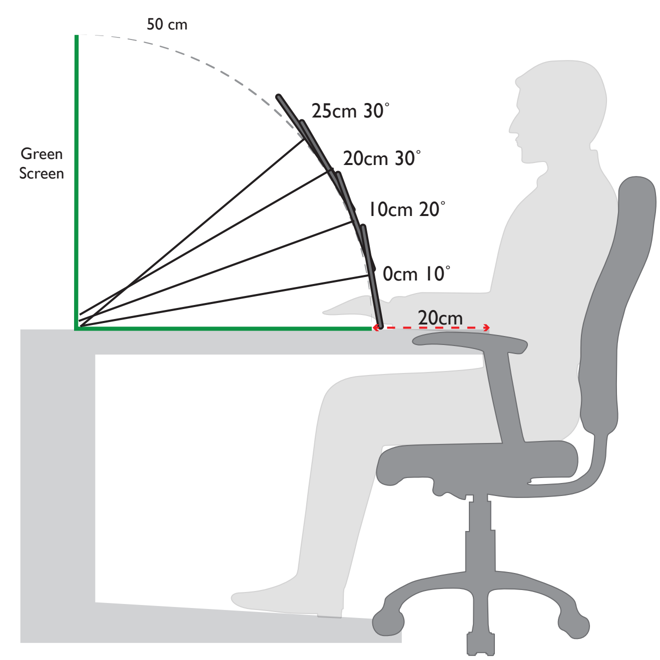


Figure 42: Heights and angles so that distanceto green screen is 50cm

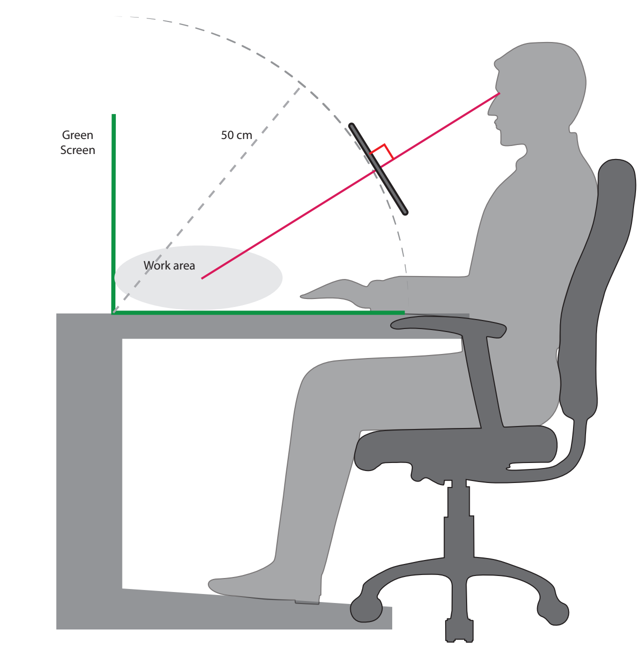


Figure 43: Hypothesis that 90degree angle with tablet is preferred

13.3 Test with different angles

In the test, which had as a goal to learn more about the parameters on the doctor side, the participants were asked to match their hands in the same shape and position as the outlines of hands which appeared on the screen. For the full test set-up and dies for the test review Appendix I and J. The test was performed with five participants, and the scenarios were in a different order for every participant to account for learning effects. The tests were timed, videotaped and responses were collected using the Nasa task evaluation index(TLX), observations from video and open questions(Appendix I).

From the results(Appendix J) several conclusions can be drawn. Scenarios three and four or (20cm at 30° and 25cm at 30°) give the best results. The average scores of the Nasa Evaluation Task index are shown in figure 44. For all the scores the 3rd and 4th scenario give better scores. Especially mental demand, physical demand, effort and performance are much better.

By far, the 3rd and fourth scenario are the preferred setups as they give the most room underneath the iPad to move the hands around freely. In the 1st set-up the iPad is at the table level, so when they have to reach with their hands, they start hanging over the iPad and can no longer see the iPad very well. Also, the width of the iPad in combination with the arm in the set-up was hindering the actions of the participants. The other issue with the first set-up was that they were not able to achieve all actions was because the work area was too small, the green screen was too close to the camera. The second scenario did not have the issue of the work area is too small, but the participants do feel they do not have enough room underneath the iPad to work with.

All of the participants have no problems keeping their eyes on the iPad in any of the set-ups. Only participant 4 mentions that the iPad comes a bit close to the face when having to reach for some of the farther actions. In the observations, it is clear that, though the participants feel they can keep their focus on the iPad they do have to move to twist and turn their bodies in some scenarios to keep their view on the iPad (Figure 45). Keeping a good view on the tablet is key as all only look at the iPad when performing their actions, not their real hands.

The main take aways from the test have been summarized in figure 46.

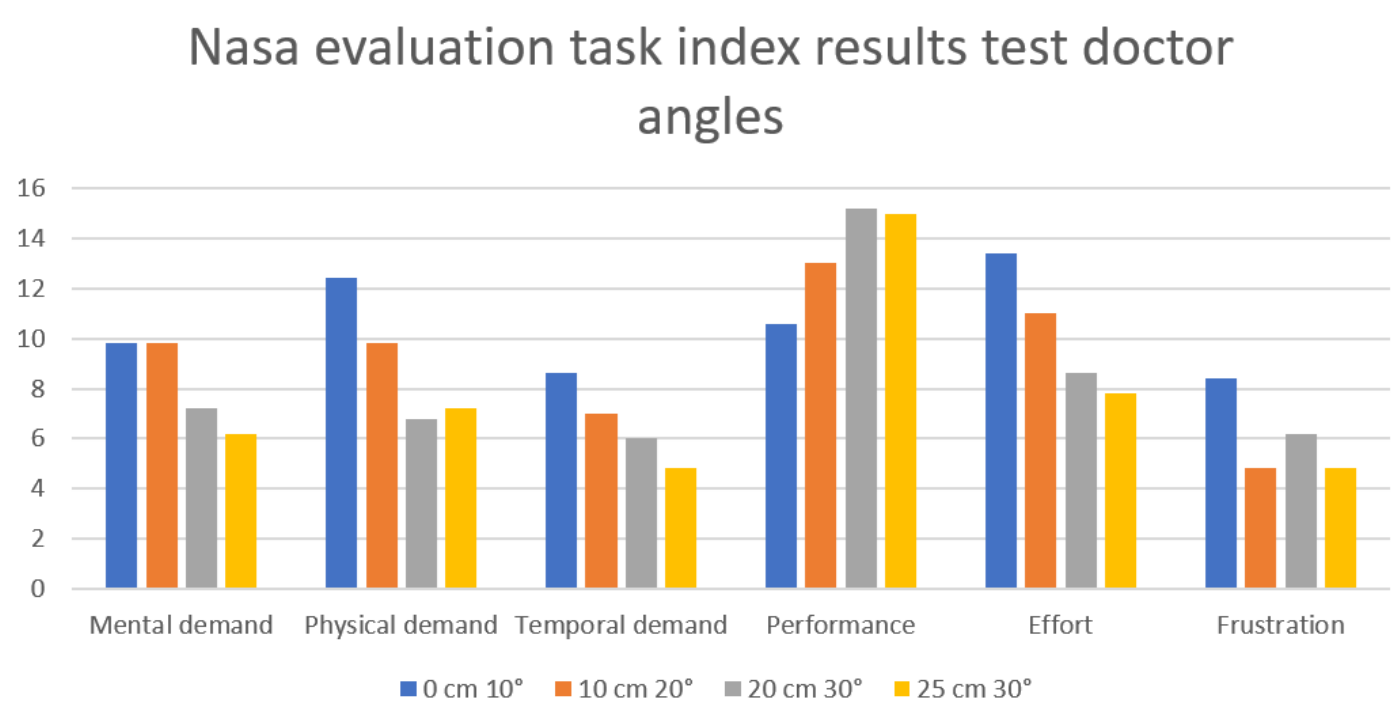


Figure 44: TLX scores angle tests doctor set-up

Figure 45: Particpant struggeling to see the screen when moving forward

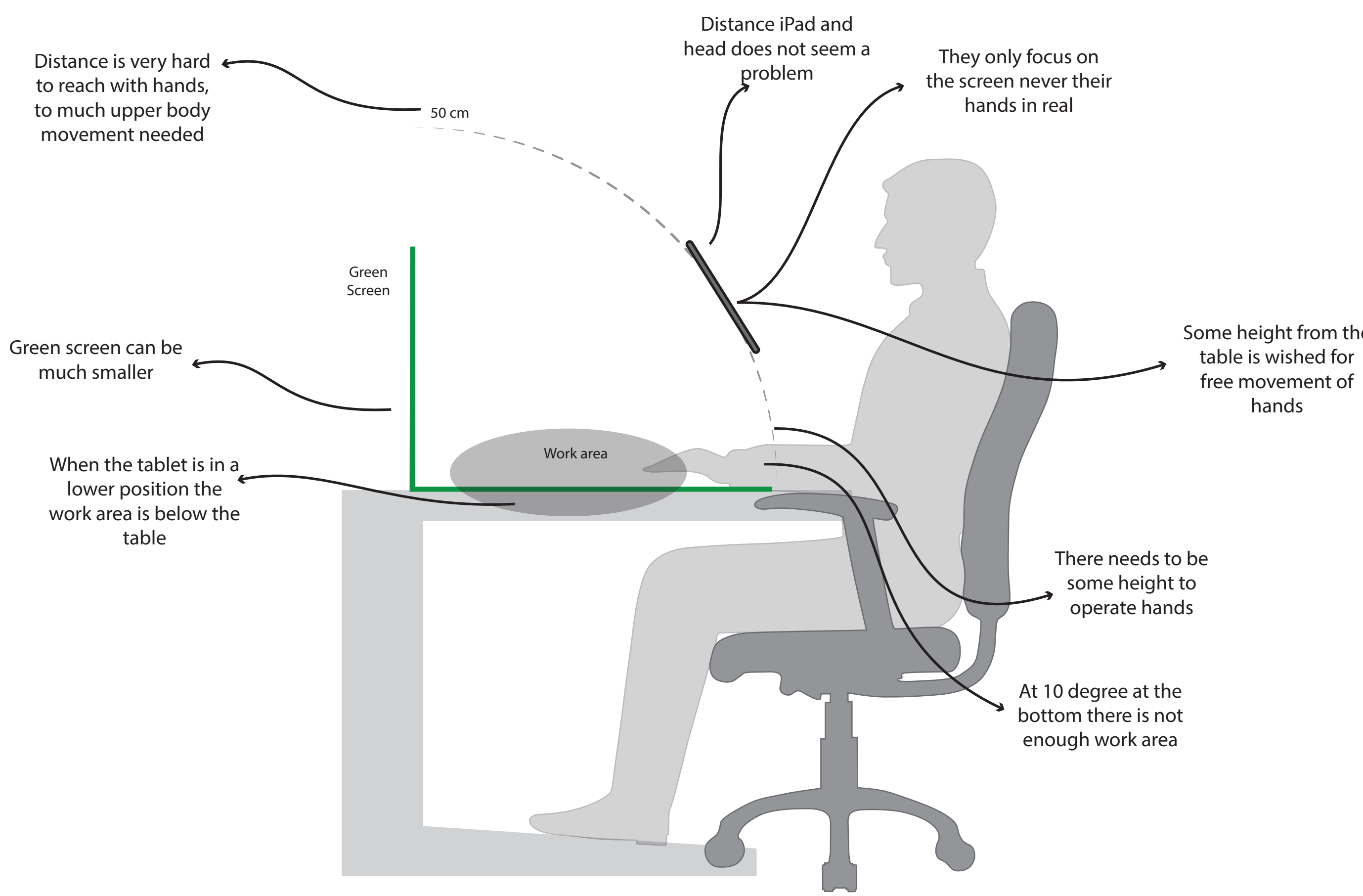


Figure 46: Results test different tablet postions doctor

05

Embodiment

14 Captain

14.1 Requirements set-up

This is a list of requirements created based on the analyses and test. In figure 48 the set-up for the three medical scenarios is illustrated.

1. Overall
   a. The set-up should be flexible to connect to multiple surfaces
2. Camera
   a. Needs to work for different scenarios and placed in line with captains view
      i. Top view body
      ii. Close up arm
      iii. Close up eye
   b. Adjustable with one hand
   c. Flexible to be adjusted mid-scenario
   d. Flexible in all directions
   e. Create a stable image
3. Tablet
   a. iPad 2018
   b. Have a stand
      i. Flexible in height
      ii. Flexible in angles

General

The situation on board of the ship has not been evaluated in depth so it is hard to say what the set-up should look like exactly to function on board of a ship. To function the requirement set was that the mounts should be flexible and attach to multiple surfaces. For both the doctor and captain side up to this point iPad stands were used with a simple screw on mechanism which works fine, it even has a suction cup mechanism which can be used to connect to surfaces that do not have an edge.

Camera

Three scenarios were considered for which the set-up should work which means it has to be able to go high from the table as well as stay very close. Also, the camera has to turn and bend to be put in the right position. The maximum height the camera needs to achieve was set at 100 cm after reviewing the view of the camera when placed this high over a body(Figure 47).

To be able to adjust the camera with one hand a handle is envisioned to be connected to the camera. This will depend on the sturdiness of the arm to which the camera is connected how necessary this is. It has the added benefit that the direction the camera is pointing at and the handle can be put at a 90-degree angle to help with understanding what the top and bottom of the camera is.

Figure 47: Testing the required camera height for abdominal search

The arm to which the camera is connected should be highly flexible, so the camera can be rotated up and down, left and right and even bend around the corner. This flexibility should not influence the stability of the camera as one of the conclusions from the satellite research was that stabilising the video feed makes for a much lower data need and higher quality image.

Tablet

The doctor should also make use of the iPad as a tablet which is similar to the doctor that this is the chosen platform for MedAssist.online services and the technology was envisioned to be used on this. The tablet should be able to be placed behind the work field which means it needs some flexibility in height and rotation which the stand used within the test so far offers.

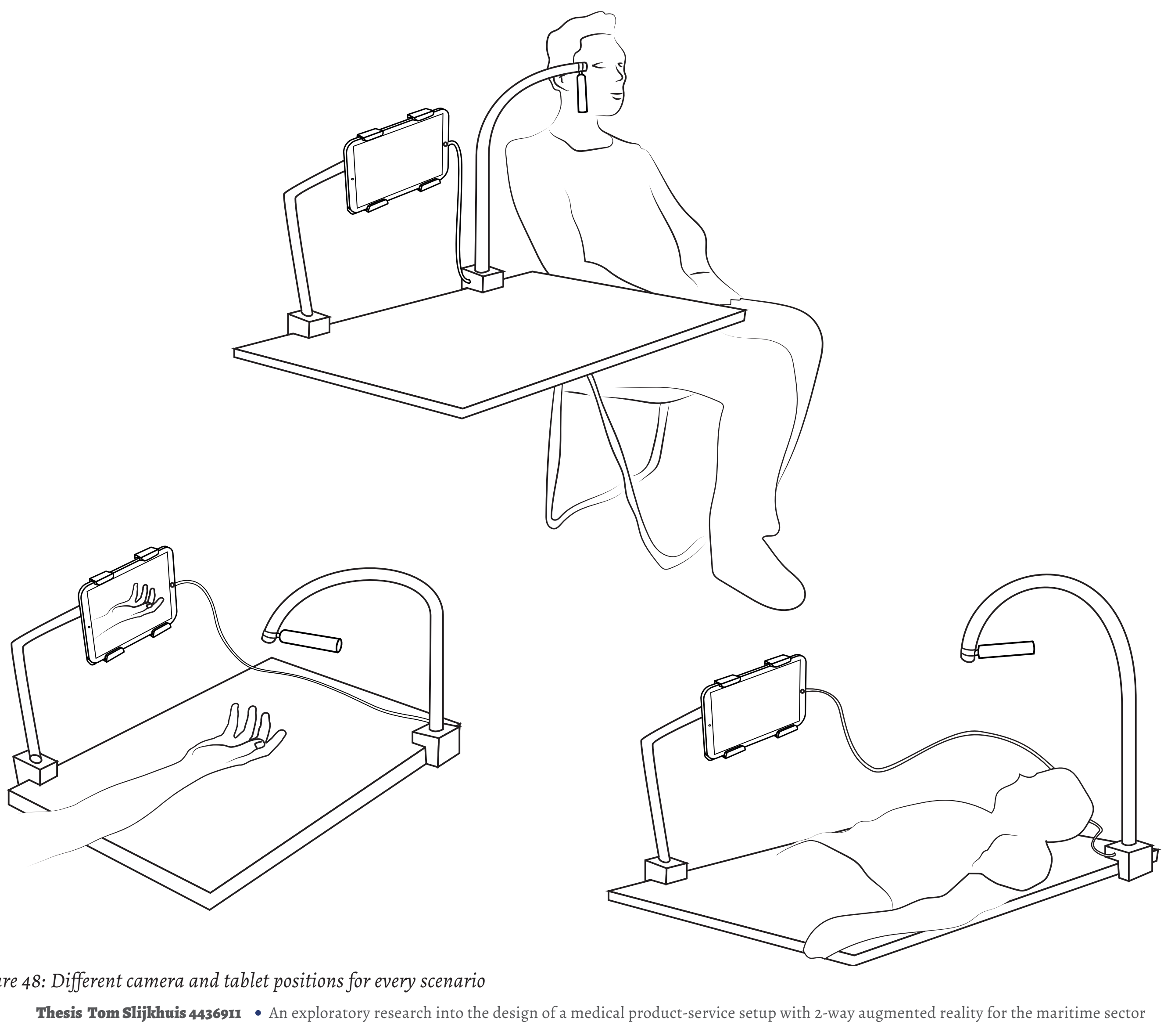


Figure 48: Different camera and tablet positions for every scenario

14.2 Final set-up

The set-up which was envisioned for the project has been visualized in Figure 49 with the different parts and requirements. With these requirements and the design in mind, a prototype set up was created(Figure 50).

The prototype set-up uses an endoscopic camera connected to an old windows tablet, as this was the only tablet which at the moment was able to recognise the camera as an input. The arm on which the tablet is placed is the familiar arm from other test set-ups.

The endoscopic camera is wired through two flexible goosenecks with a total length of 108 cm(Alle Kabels, n.d.). The goosenecks are commonly used for microphones but have the right flexibility and inner diameter for this project. The goosenecks are screwed on to each other and onto a table clamp which can be screwed onto surfaces very similar to the iPad stand(Conrad Electronic, n.d.). The clamp was modified so that the camera was able to run through. The handle is made from a bike handle and aligned with the perspective of the camera.

For the initial prototype, the idea was to use only the goosenecks connected. Unfortunately, when they are connected, they are too heavy and would continuously bend over. To overcome this a piece of pipe with a 22mm diameter was put around the lower gooseneck. This put the point of flexion higher above the table and reduce the amount of weight that is acting in the point allowing for the camera to stay in a stable position.

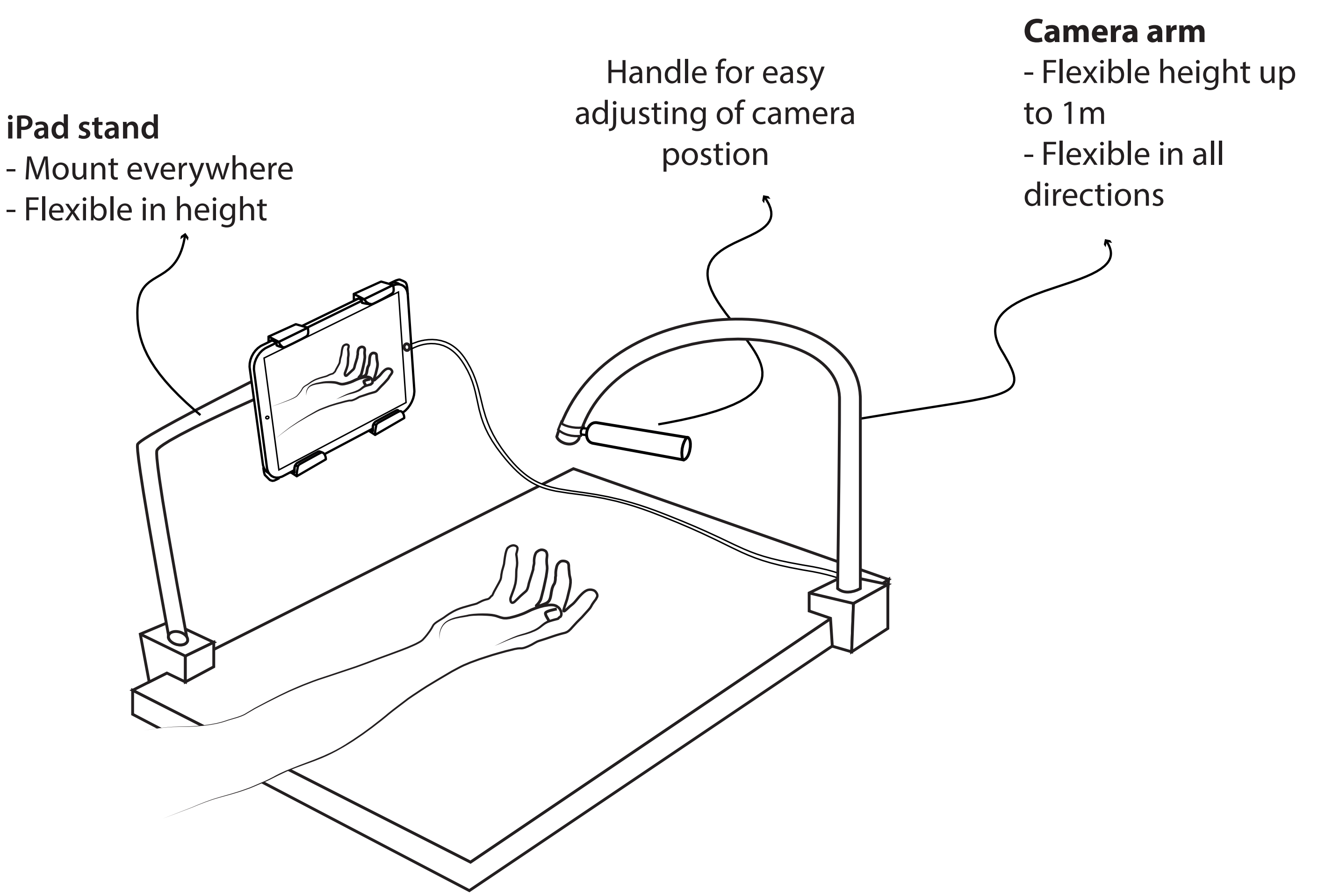


Figure 49: Parts to captains set-up


Figure 50: Prototype of captain's set-up

15 Doctor

15.1 Input conceptualization

In the conceptualisation phase the parameters relevant for the doctor set-up are defined:

1. iPad height from table
2. iPad angle (measured in relation to table)
3. Distance from iPad to the green screen
4. Size green screen
5. Distance iPad to eyes --> distance iPad from the table edge

To define these parameters a test was performed. The test with the different angles and heights of the tablet has give input for the embodiment of the doctor set-up. The following conclusions were drawn:

- 70 cm from the table edge to the end of the green screen is too far to reach
    - o The eyes get too close the tablet
- The green screen set at 50*50 in both planes was not fully utilized so could be made smaller
- The angle of the iPad in relation to the eyes/head does not seem to influence the experience
- The iPad is preferably higher than 20cm from the table so it does not block hand movement

The last conclusion was that the participants were very comfortable looking through the tablet on to their hands. They did not feel the need to look around the iPad to see their own hands in reality when performing actions.

It is not about the distance of the iPad to the green screen is also about the size of the work area. During the angle test the first two setups, which are lower to the table, proved to be problematic as some of the actions could not be performed as the green screen on the table would be in the way. This is determined by the position of the tablet in combination with the field of view of the camera which needs to be put so that a large as the possible work area is created.To work towards a more detailed set-up, these parameters have to be defined in more detail.

15.2 iPad height from table and angle

From the test with different heights and angles of the tablet could be concluded that the performance increases when the height of the tablet is 20+ cm from the table. The main reason for these heights performing better is the freedom underneath the tablet. In the interviews, the participants pointed out that it was not uncomfortable to keep looking at the iPad. The assumption that is most comfortable to have a 90-degree angle between the tablet and line of sight into the work area was not disconfirmed. Using DINED(2004) data the new height and angle of the set-up was determined.

In Figure 51 the p5 and p95 sitting heights are sketched in relation to the table, and the blue dotted lines represent the line of sights to the furthest point of the green screen which cuts straight through the centre of the work area. The lines are drawn for the p5, p50 and p95. For reference, the p50 line is used.

When the centre of the tablet, where the camera is, is aligned with the p50 line of sight and a 90-degree angle is created between the iPad and line of sight the table the angle between the tablet and table is 40 degrees, and the bottom of the tablet is 30 cm from the table.

To increase the size of the work area, the centre point camera was aligned with the 20cm from the table rather than the bottom of the camera. This is considered possible because the iPad came close to the face sometimes in the tests, but this was because they had to reach. In the new, smaller green screen set up, this should no longer be an issue, and the doctor can sit up straight.

Requirements:

- 40-degree angle
- 30 cm from table
- Camera 20 from the edge of the table

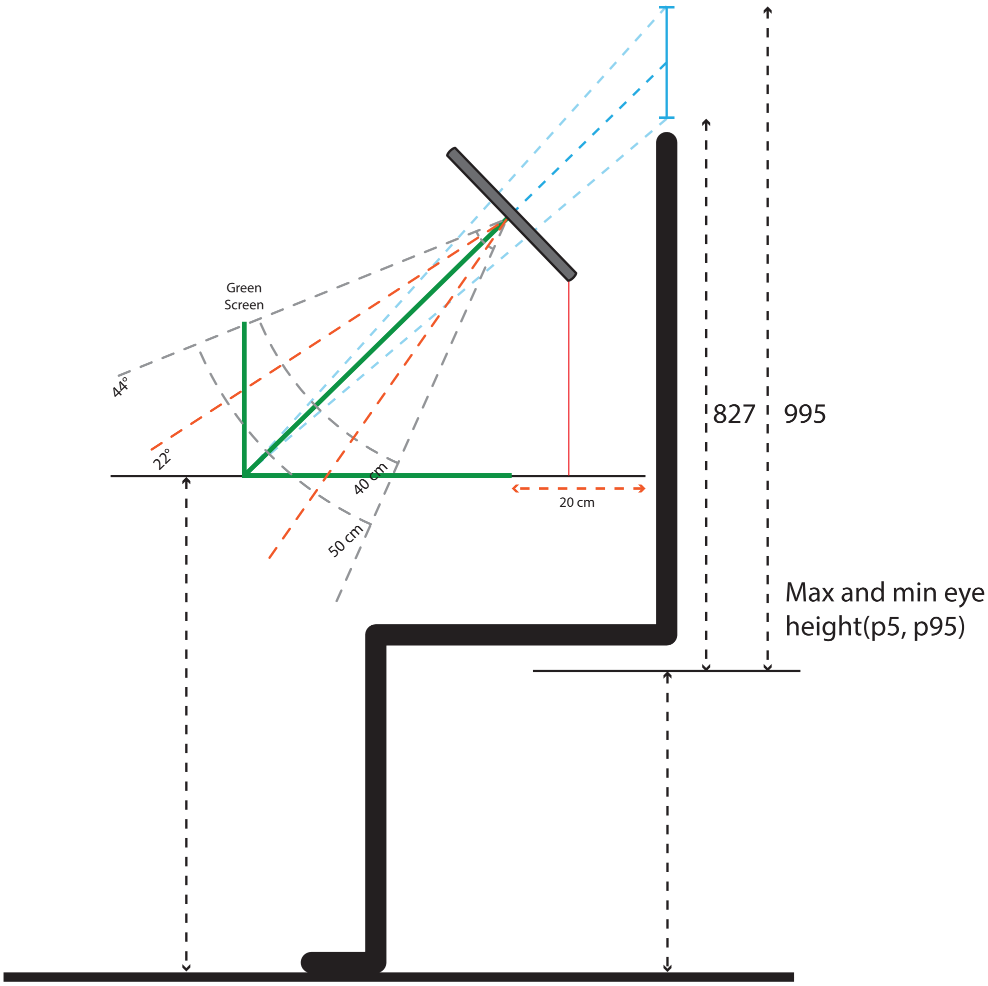


Figure 51: Sketches to determine the size of the green screen and size of the work area

15.3 Distance iPad to the green screen

The first conclusion about the distance of the green screen from the table edge makes sense in retrospect. In the conceptualisation phase the arm length is measured when the arm is completely extended. This is of course not realistic when sitting behind a desk where the arms are already slightly bent. This would mean the max reach is in a straight line forward from the shoulders which would conflict with the iPad in between. The comfortable reaching distance when seated behind the desk is the relevant measurement for this set-up.

DINED has another tool with reach distances, the tool indicates the comfortable reach distances for p5 to p95. The horizontal distance for p5 is defined at 64,5cm and 82cm for p95. This is much in line with the arm length used as input in the previous set-up and does not help with defining the parameter. Though the tool gives some insight into what the maximum comfortable reaches distances are for people, it is very much in line with the average arm length used as input for the first set of parameters. To get a better understanding of what is an ergonomically comfortable some more research was done and some illustrations were found on what Relax the back calls the 'ergonomic cockpit'(Relax The Back, 2017). In figure 52 such a cockpit is defined by the US ergo, in inches(US Ergo, 2018). When calculated into cm the distance for a maximum work area for men is 67,31 cm and for women 59.69. For the new set-up, it is chosen to keep the maximum distance of the green screen from the table edge at 60cm.

Requirements:
- Green screen max 60cm from the table edge

15.4 Work area

To increase the size of the work area the iPad has to be higher up as Figure 53 clearly illustrates. The change in angle and increase in height positively influence the size and depth of the work area.

The angles of the iPad camera were measured and calculated because there is no data available by Apple. The vertical FOV, when the iPad is in horizontal position, was calculated to be 44 degrees. The FOV was sketched out, as can be seen in figure 53.

15.5 Final set-up

1. iPad height from table + 30 cm to the bottom corner
2. iPad angle (measured in relation to table) = 44 degrees
3. Distance from iPad to green screen = 50 cm+ measured from camera
4. Size green screen = big enough, so it works for test
5. Distance iPad from table edge = 20cm to camera

The strength of the new set-up is visible in figure 53. The tablet is put in a higher position slightly closer to the user with an increased angle. This allows for a large work area to be maintained with the maximum depth exceeding 50cm without exceeding the 60 cm distance from the table edge. The final set-up was prototyped of which picture is in Figure 54.

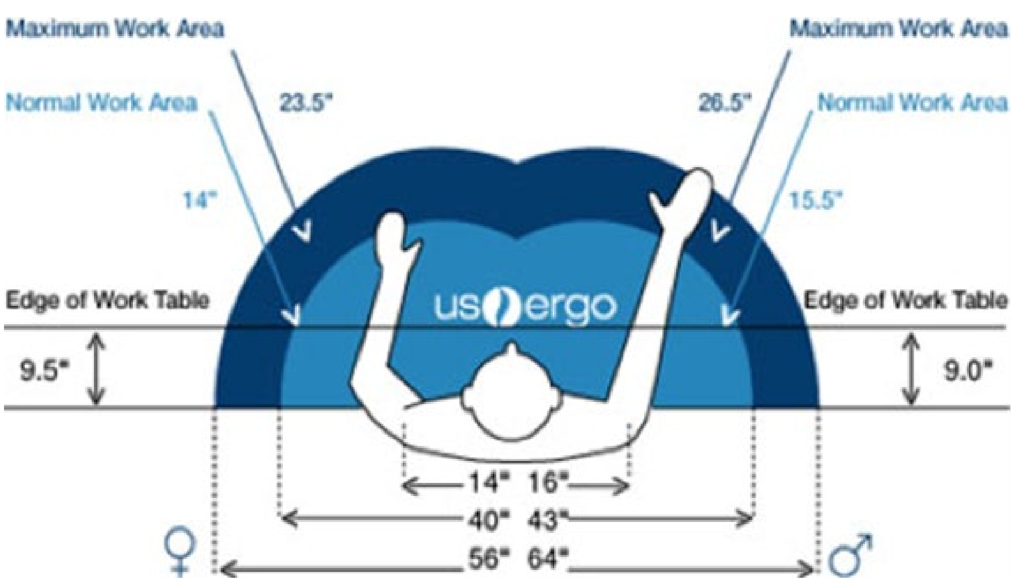


Figure 52: Ergonomic cockpit(US Ergo, n.d.)

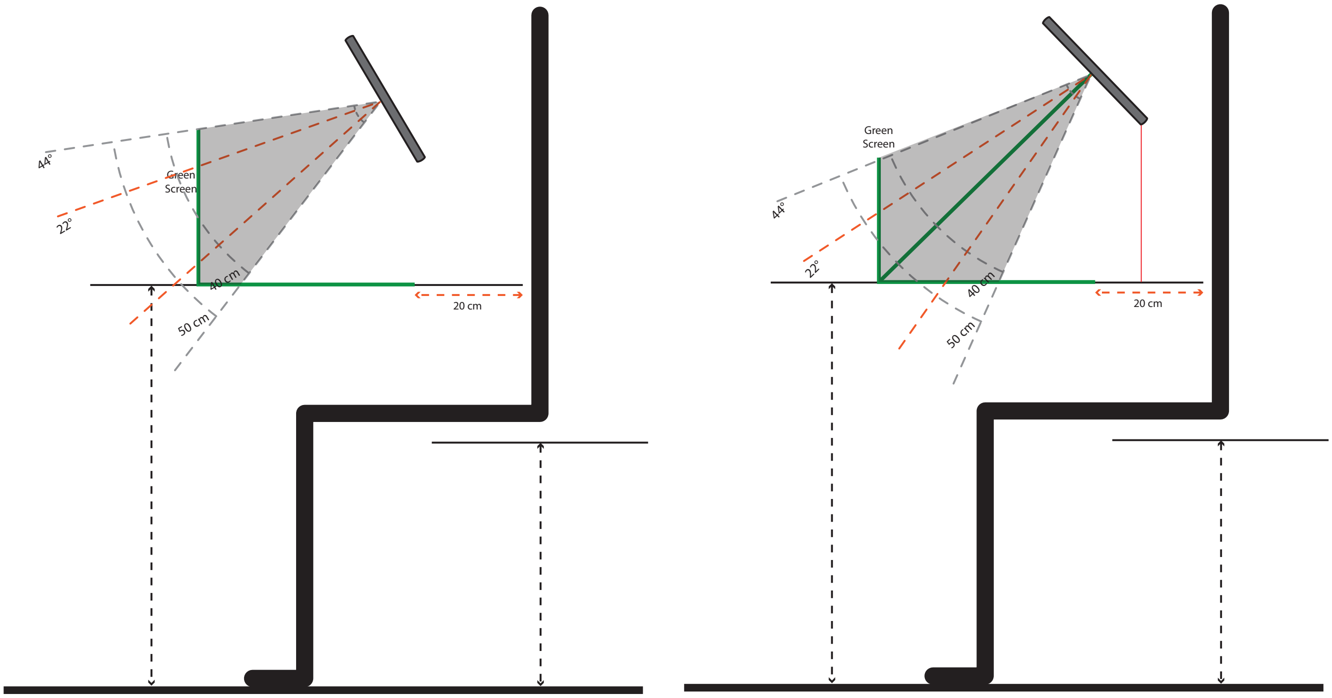


Figure 53: The work area increases in size and depth when the tablet is positioned higher and at an angle

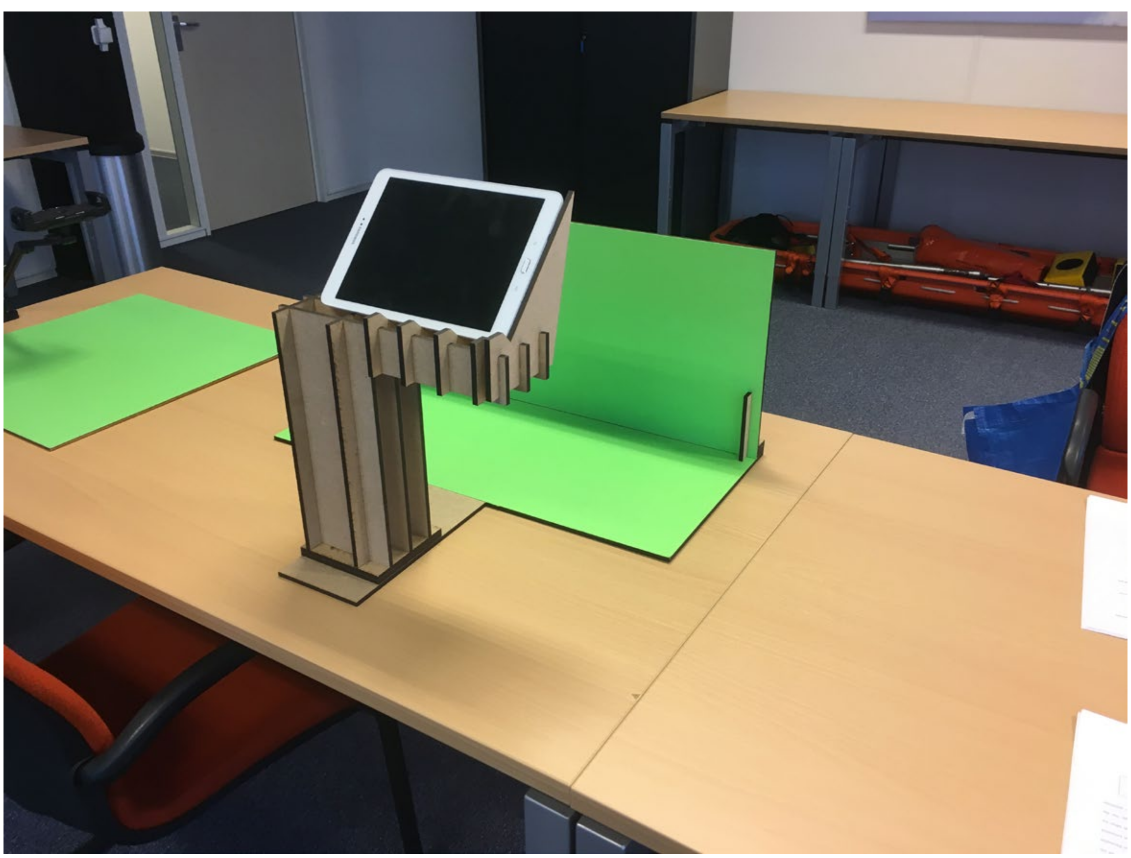


Figure 54: Prototype set-up doctor side

16 Application

16.1 Input for application

The analysis concluded that the captains are not just looking for support in the treatment phase when performing skills. The captains have a general feeling of insecurity and lack of support throughout the whole journey. The AR functionality will play an essential role in the treatment phase to add confidence in actions through the support of an expert but does not have a role in the other phases.

Not just the captain, but also the doctor has needs which surpass the need for a video feed of the patient to give instructions. The RMS doctor has pointed out the need for good data collection about the patient before he can give the right support. In addition to this, the training doctor pointed out the value of an overview image to be able to 'treat what kills first'.

The needs described above transcend the AR functionality and led to the realisation that the application should be more significant than the AR-functionality and become a service that aligns with the journey and has functions which fulfill the needs of the captain and doctor. By working towards an app which fulfills these requirements the product can move from a live video conferencing product with 2-way-AR to a telemedicine service with 2-way-AR functionality.

16.2 Aligning with journey

For the application, a selection of functions was made which were considered most important in fulfilling the needs of doctor and captain. These functions are in line with the needs identified in the analysis phase and described above. At the same time, the functions implemented had to be limited so that that the development to a first version of the application was kept within a realistic time frame. The following functions were suggested for the application:

- Captain side
    - o Structured data collection patient
    - o Photo function to create a photo of the incident
    - o Chat
- Doctor side
    - o Draw on photo
    - o Chat

In figure 57 these functions have been integrated into screens and plotted against the journey to match the timings of the functionality. To facilitate the understanding of the application and the documentation the 'case' was put central in the flow. A suggestion for the design and content of the case screen was made(Figure 56). The case is also the first choice the captain has to make when opening the application. Will he continue with an open case or is there a new incident.

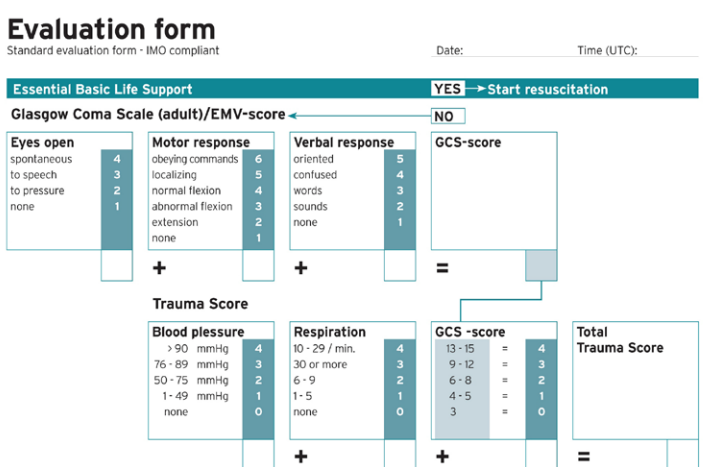


Figure 55: Data collection on patient for doctor

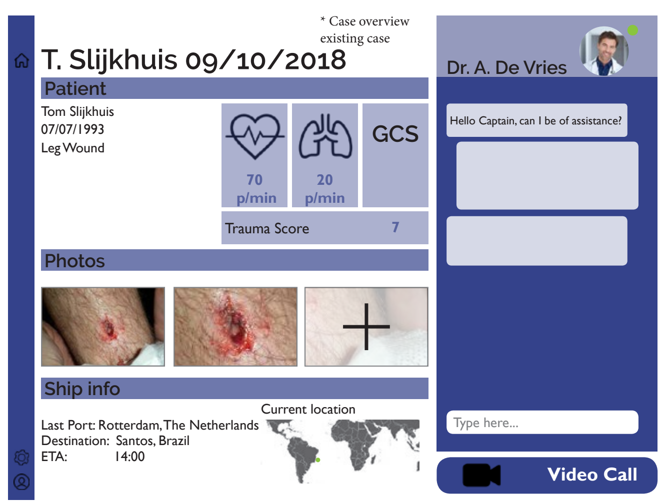


Figure 56: Case screen design

If the captain opens a new case when he is in the 'judge and stabilise' phase, he will be guided through the structured data collection process. In the structured process he has to fill in the patient details or select him from a list and is taken through screens which invite him to fill in vitals in line with the patient evaluation form(Figure X). All of this information is added to the case and will be part of the overview as presented in Figure X. The doctor(s) will receive a notification that a new case has been made and can choose to review it.

From this point onward the doctor and captain are in the 'analyse and diagnose phase'. The captain continues to get more elaborate information on the patient as the Patient evaluation form suggests(figure 55). The doctor can review the first patient data, photos and ask the first questions through chat. The captain and doctor can now inform each other through the chat function, and the decision can be made what the right moment is to set-up a live connection.

In the treatment phase, it is the live connection with the AR-functionality at work. In the after-care, the case based set-up allows for the doctor and captain to stay in touch. The RMS doctor in the interview explained how he often does not get responses to emails or does not ask for a follow up; it is not his role. According to the doctor of the training centre, there are medical scenarios where it is beneficial to keep track of the vitals and see a potential trend line. Doing this too often might be too much for the captain, but at least having contact with the doctor after and talking about the patient to make sure the patient progresses is monitored. If the patient is stable and taken care of the case can be closed.

During the analysis phase, there was often discussion about the difference between acute and non-acute scenarios. This main service value is in the non-acute scenarios when the patient is, relatively, stable and skills are performed. In an acute scenario, there is a need for direct action and the remote doctor is of less value. It is still possible for a crewmember to set-up a connection with the doctor and asks for help, but the focus is on the support on skills.

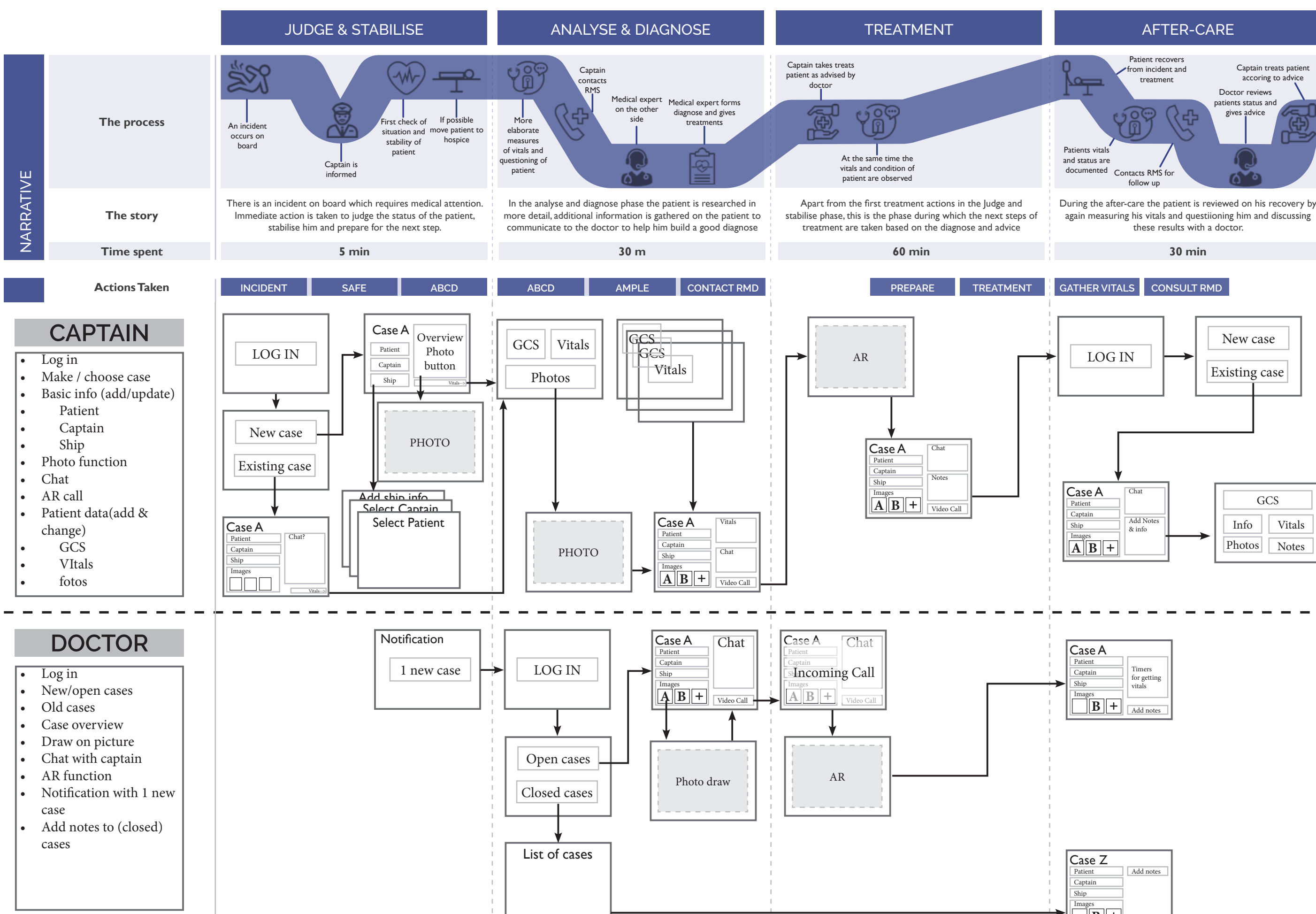


Figure 57: Application functions aligned with customer journey

06
Evaluation

17 Final Test

17.1 Test set-up

The goal of the test is to see how well the developed set-ups on doctor and captain and doctor side perform in comparison the envisioned set-up which uses only two stand and two iPads. The test tries to find indications of increased performance of the 2-way-AR functionality on communication, ease of understanding of the situation, ease of understanding and giving of instructions with the hands. At the same time, the test was also focussed on the ease of use and ergonomics of the set-ups and the use of the features, like flexible camera position on the captain side and control over hand size on the doctors for example.

The scope of this test is to see the full set-up in action in comparison with the previously envisioned set-up(Figure 59). This is done with an as realistic possible medical scenario so that it requires communication.

The first set-up of the test is the envisioned set-up which the project was once started with and is shown in figure 58. The doctor has a downward facing iPad which is held up with an iPad stand. The captain has the same iPad stand with an iPad in there

During the test, the participants have to set an IV using instructions received through the AR application(Appendix O). Halfway the scenario they have to stop, and they are asked to fill in the Nasa Task Evaluation Index, and the set-up is changed after which they continue. Ideally, the test is performed with a medical professional on one side and a captain on the other; this was achieved three times. If there was no medical professional available due to the time pressure of the training, the role was fulfilled by the interviewer.

The results were evaluated through questionnaires, observations from video material and interview questions. The doctor and the captain had slightly different questionnaires but with similar focusses(Appendix P). Limitations to the test were that only one scenario was tested, setting an IV and that some of the participants had practised this skills very recently in the Medical Care training. Another limitation was the availability of only two medical experts during the week to perform the test with. So only three test could be performed as it was intended with a participant on the doctor and captain side.

In the test 6 participants took part on the captain side with an age range of 25-59 and one female and the rest male. Out of all the participant, only one had extensive experience with setting an IV, the rest none or just in training(Appendix Q). On the doctor's side, two trainers from the medical training centre participated whom both have extensive experience in giving instructions. One of the two did the test double as he did his first with the experienced captain and could hardly give any instructions. With their participation, the test could be taken three times as it was intended with a medical professional on one side and a captain on the other. The other three occasions the role of the doctor was fulfilled by the interviewer.

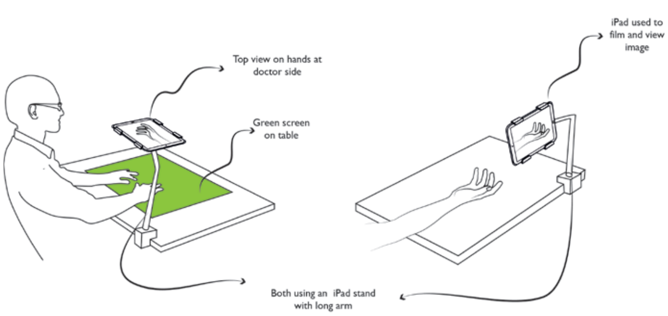


Figure 58: Set-up 1 for test

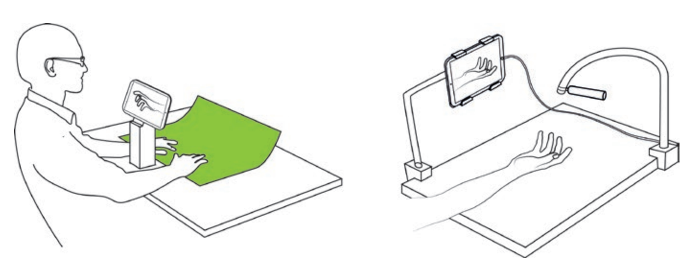


Figure 59: Set-up 2 for test

17.2 Results final test

Captain

For mental demand, physical demand and effort the scores for set-up two are 0.8 lower than the scores for set-up one which means they are slightly better for set-up one(Figure 63). The performance is also better for the second set-up with a factor of 1.2. The score for frustration is nearly equal between the two set-ups — the only parameter where set-up two was scored worse than temporal demand which is 1.4 times higher than for the first set-up.

The reasons why set-up 2 performs better on mental load, physical demand and effort and higher on performance can for a large part be contributed to the fact that the camera is disconnected from the tablet. The disconnection allows the captain to place the camera easily in the desired position while keeping the focus on the tablet(C1-C6) as is clear from figure 62. In their responses to the interview questions C2, C3, C4 clearly state they prefer the second set up as it is easier to keep eyes on the tablet and because it leaves an open work field.

Set-up 1 creates a whole range of challenges for the captains(Figures 60 and 61). The screen of the tablet is not

Figure 60: Impossible position to view the tablet

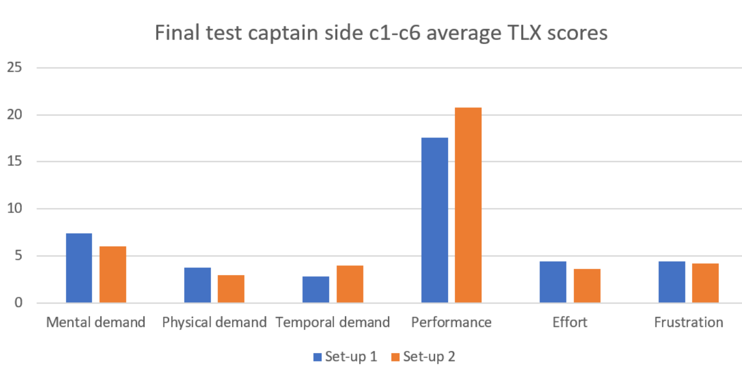


Figure 63: TLX scores captains

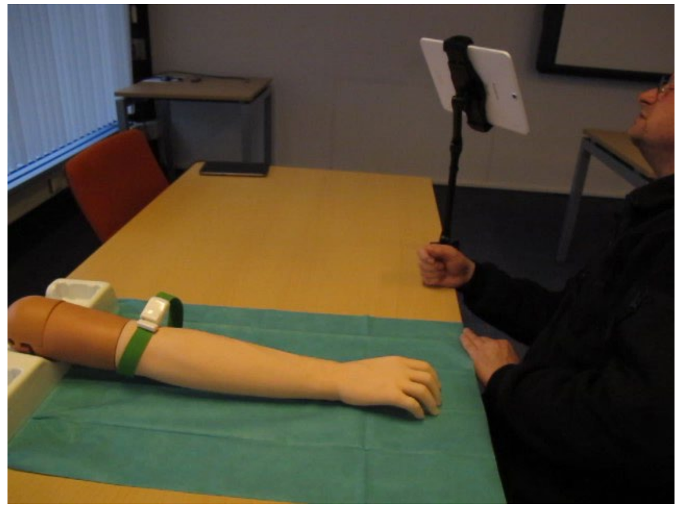


Figure 61: Tablet behind work area

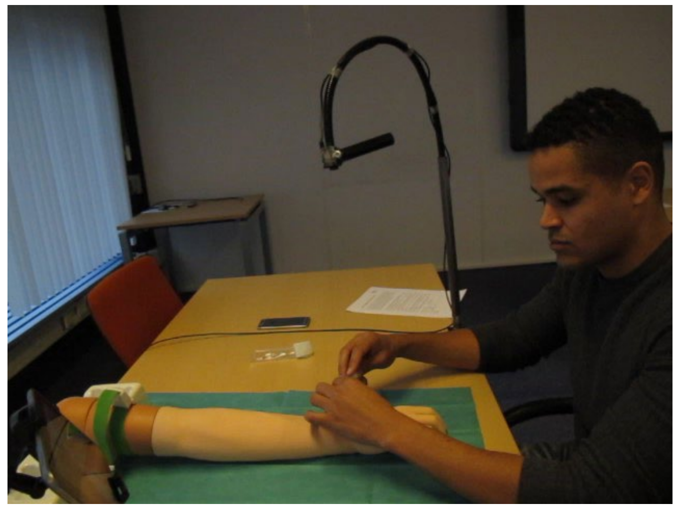


Figure 62: Tablet in comfortable position to view over work

visible because it has been placed behind the captain or it is in the way of his actions. There are two potential reasons why temporal demand might be higher for set-up 2. The first is that the quality of the camera was significantly lower for this set-up as pointed out by captain C3 and C5. However, this would most likely have had a higher impact on the scores mental demand and effort. The second reason is that with set-up 1 since it was impossible to view the tablet and work at the same time, the communication and actions were more split. Every time they were receiving instructions they would have to pause their actions and re-position to see the tablet after which they could continue their actions. Set-up B allows for more seamless communication which could lead to faster instructions of the doctor and thus lead to a more rushed feeling.

None of the captains experienced a difference between the hands of the doctor between set-ups one and two. C1 and C3 point out that it is, all the same, you see fingers and hear the audio. Overall the captains, also in this test, see the value. They like the double confirmation of the audio and hands(C6) even with experience it is a good feeling to have someone watching and giving tailored instructions.

Doctor

For the doctor's average scores on the TLX, there is even less variation between the set-ups than with the captain. Overall the performance of set-up two is scored marginally worse than the first by a factor of 0.9(Figure 64). Temporal demand, effort and frustration all score higher for set-up two with factors of 1.1, 1.2 and 1.1 respectively. Only mental and physical demand score better with a lower score for set-up two with 0.8 and 0.8 respectively.

The advantage of set-up on is the ability to change the position and angle freely to their desires which D1 immediately did. The effort is the outlier on the scores with a factor of 1.2. Based on the observations the assumption was that this is because it takes the effort to raise the hands into the work area(Figure 66). However, the physical demand is scored lower for set-up 2. It is more likely that the effort is so high because both doctors pointed out the reflection of the light above on the tablet screen made it hard to see.

With set-up one the captain can give the doctor a good overview but as soon as the captain starts performing the skills he is very likely to block the view with his hands or body(Figure 67). This experience is not reflected in the sores; the doctors do not consider this as the performance of the set-up.

In the interview questions, D2 pointed out that he felt his hands were a bit big in screen and bigger than in reality. The same accounts for D2 he even explicitly mentions that he feels his hands were too big and he could not always achieve the detail he wanted. Neither doctors tried to move their hands further away. With set-up B this is also harder, they already feel that they have to reach further. From the observations, it is clear that the set-up is too high up and too close to the face.

Figure 65: Doctor changed set-up 1 to his wishes

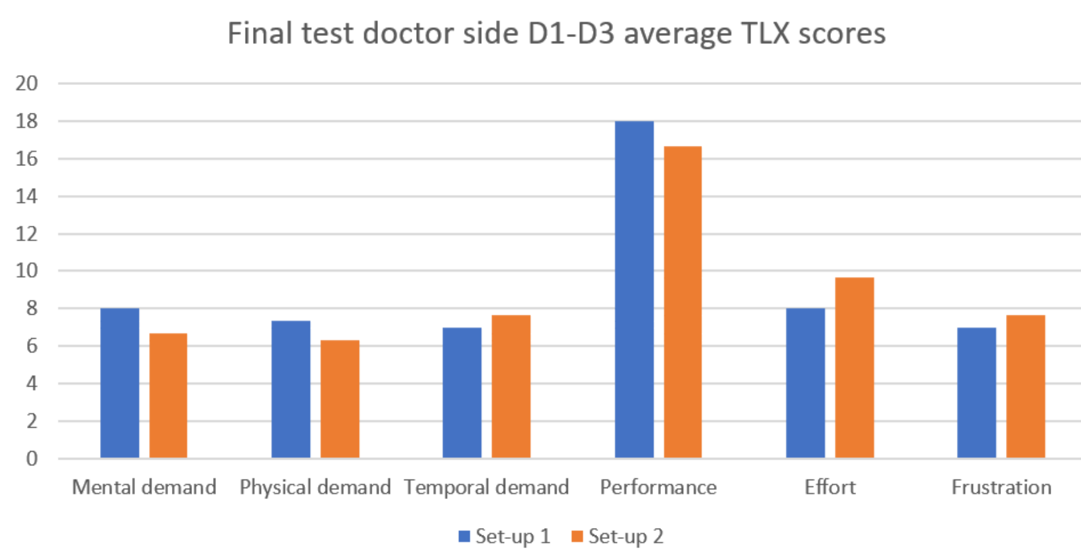


Figure 64: TLX scores doctor for test set-up 1 and 2 in the final test

Figure 66: Hands have to be kept high up to get them in the work area

Communication

More and more it is becoming apparent that a vital part of the product-service is the communication. The focus on communication is on the understanding by the doctor of the captain's situation and the captains understanding of the hands by the captain.

Multiple captains(C1 and C3)point out the limited functionality of the 2-D hands, and also D1 experienced this when giving instructions. He stated that it might be helpful to have some tools to show actions with. For this test, the cannula the captains were using to set the IV for example. Though the doctors did feel the hands were on the larger side to give instructions the captains experienced very little difference.

In the positioning of the camera, the doctor's needs are leading. In the conceptualisation, it was assumed that a camera position in line with the captains perspective would work best. However, in practice, it turns out the view needs to change for the doctor to understand but also give the right instructions, for example, a side view of the needle on the arm to determine the angle. This is not the same perspective as the captain, but it is the best perspective for the doctor to understand and show.

The most important conclusion is that there is a need for practice or a communication protocol. Even in set-up B where the captain can see the screen easily, he will still need to shift attention. When the doctor is giving instructions, but there is no focus of the captain they go to waste influencing the performance.

Figure 67: Captain blocking the view for the doctor

07

CONCLUSIONS

18 Recommendations

17.1 Captain

For the captain's set-up it is recommended that the system consists of the following parts:
- iPad
- The camera on an arm
- iPad arm

For the final set-up, the biggest challenge is to find a new set-up is a camera. The desired set-up has a flexible stand with a table connection on to which a camera can be screwed or is embedded like the iPad stand in Figure 68. The hard part with either set-up is that it needs to be able to connect with the iPad and be recognised as a camera input.

For the iPad arm, it is advised that MedAssist.online dig a little deeper in the needs on board. The current arm is flexible enough, long enough and can be placed on multiple surfaces. The limitation of the arm is that the axes have to be tightened very well making it hard to move the iPad around.

17.2 Doctor

For the doctor, a set-up was explored based on the assumption that the captains needed more control over the size of their hands and how the set-up could facilitate this control.
- iPad
- Green screen
- iPad arm

The need for control over hand size is still relevant, but the size of the work area can be smaller for two reasons. The first is that the camera in the 2-way-AR application in development is more zoomed in than it needs to be. So it magnified the hands more so a very large range(30-50cm) was set. It is advised that MedAssist.online review the hand's sizes and go back to the envisioned set-up with an adjustable arm with the tablet at a slight angle. For extreme scenarios where the patient is very far away like with the abdominal search for an example that a zoom function is built-in in the app controlled by the doctor so he can digitally control his hand size. Lastly, it is advised for the doctor set-up to turn the flash on so it is easier for the app to distinguish the hands from the green screen.

The size of the green screen will have to be recalculated so that it accommodates for multiple set-ups of the tablet. The arm with a foldable green screen would make that the doctor can carry it anywhere. If the doctor set-up is more permanent a more stand like the design could be made, as was done in the project, with more control over the angles and position, so the camera never films around the green screen. This decision will depend on the set-up of the service if the set-up can be in a permanent location.

If the set-up would be more permanent in for example a doctors practise or hospital it has another advantage. This would give access to tools to help the doctor better show what to do. A pen could be enough, but it might be beneficial to consider adding a small selection of medical tools to the kit to help the doctor.

17.3 Application

In the design challenge, there were two overarching goals. The first was to increase the confidence of the captain by increasing the feeling of support with more interactions with the doctor throughout the journey. The second goal was to improve the set-ups so that the 2-way-AR technology could be used as intended.

In the application, the first steps have been taken to increase the number of interactions by adding a chat function, photo function and structured data collection process. It has not been validated if these functions increase the feeling of confidence as the focus has been on the set-ups for 2-way-AR. The assumption is made that, based on many responses in the tests, that the feeling that someone is working with you ready to step in will achieve this. In the treatment phase, where 2-way-AR is used this, of course, the case, and many participants point out the functional as well as the emotional value of working together and sharing the responsibility. There as some functions that are not in the current app but which can be integrated towards V2 to make interactions more natural and more structured:

- Pre-set questions from the doctor as responses in the chat
- Checklist with instructions per scenario which can be shown when video calling to help captain understand where in the procedure they are
- Draw function on the photos taken
- Timers for data collection on the patient in the after care to monitor the patient

To make 2-way-AR work, the set-ups on the captain and doctor side have been developed and tested. Though, especially on the captain's side, the new set-up added value for the captain to use the instructions they did not experience any difference in the AR instructions. The same counts for the doctors who did not experience much difference between the two set-ups in and extend to which they were able to give instructions. In the current functioning of the hands it is very much pointing and showing, it is not a 3D animation of the actions that the captain can see from various sides. This makes it low cost and easy for the doctor to give custom instructions to every case. To improve the experience of AR, there are a few functions suggested for MedAssist.online to explore:

- Add shadows to hands
- Zoom function on the doctor side to control his hand's size

The last area for future development in the app is the communication between the captain and doctor. In figure X an exploration of an AR screen is presented. In the screen, a roster is added to help structure the information, and there is a button which indicates whether it is action or communication phase — this way the captain knows when to pay attention to the screen. However, on the screen, there is also an image of the doctor meant as if the face cam is on. This was added to add more confidence for the captain but can also serve a functional purpose. With the iPad being behind the work area of the captain the front camera is most likely directed at the captain. If the front camera is on during the call the call, the doctor can use the image to see if the captain is looking at the screen or patient. The second function which is less defined but could be explored is a communication protocol. The list of steps in the procedure suggested above could be a guide in this when these are shown on screen when video calling.

- Front camera functionality
    - o The front camera on as small box during video calling like facetime
- Communication protocol

Figure 68: Possible endoscopic arm for iPad and cameraAliexpress(n.d.)

19 Conclusion

This thesis was written for MedAssist.Online and the Technical University of Technology Delft and at its core is the 2-way-AR technology invented by Dr W. Boon. The thesis was written as part of a project to set-up a telemedicine solution for the maritime industry with live video calling with the addition of 2-way-AR technology.

With the increasing coverage of global satellite and the dropping prices the opportunities for telemedicine solutions with a video which communicate over the internet and have high data transfer are growing. More often than not there is no doctor on board, and the captain is responsible for the medical care of his crew. To provide care captains receive one week of training every five years with medical skills. There is no practice or training in between the five years and captains feel insecure and out of depth.

The analysis of the treatment journey and the role of the captain and the role of the doctor in the journey gives insight in the needs and feelings of the doctor and captain and what role 2-way-AR technology could fulfil in this journey. The conclusion was that, apart from video conferencing with 2-way-AR for skill support, there is an opportunity for the application also to facilitate and fulfil the needs outside the treatment phase. The app was set-up to be a service which aligns with the treatment journey, and increases the interactions while also adding data collection for better treatment and suggestions were made to improve the feeling of confidence. The challenge of the project was twofold: first was to increase the confidence of the captain by increasing the feeling of support with more interactions with the doctor throughout the journey. The second goal was to find a way to optimise 2-way-AR interaction so that the 2-way-AR functionality is a valuable addition to the live video conferencing — a valuable addition in the sense that the captain gets more value from the instructions given by hand than just the verbal instructions from the doctor.

For the 2-way-AR functionality, the tablet and camera position at the captain side were evaluated. This led to the recommendation of adding a camera to the captain set-up. The addition of a camera allows the captain to put the tablet in a position so that he can quickly view the tablet without losing focus of the patient or having to move his body because the tablet is in an awkward position.

For the doctor, a stand was designed with an integrated green screen which optimises the size of the work area so that the doctor can control the size of his hands. From testing the final set-up, it could be concluded that the size of the hands is only of minor influence on the instructions. The influence is minor on the ability for the doctor to give instructions as well as for the captain to understand them. More significant factors turned out to be the fact that the hands are presented in 2D and the ease with which the doctor can get his hands in the work area.

A returning point of attention during the project is the communication between the doctor and captain. In earlier tests, this was attributed to the loss of audio due to bad internet and the application being a prototype. However, in the final test, it became apparent that there is a need for a solution which makes sure the doctor and captain understand from one another when they are giving and receiving instructions.

Recommendations have been provided for the future development and integration of this research in the service. This project has contributed to moving away from the 2-way-AR functionality towards a service which provides support throughout the full treatment journey. On top of that, the research into 2-way-AR by evaluating camera positions has generated recommendations to optimise also this part of the service.

08

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