A Roadmap to the future of Healthcare in Barco

Master thesis Strategic Product Design

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Executive Summary

The healthcare market is changing, with technologies like Artificial Intelligence (AI) and the increasing use of patient data. In everyday practice, AI will be used as a co-pilot for image interpretation (Beregi, 2019). Additionally, public health records (PHRs) offer a tremendous opportunity to generate support in reducing costs, improving health outcomes for populations, and improving the experience of care for patients and their families (Ford, 2017). These are just two developments that will have a huge impact on the needs and the roles of the patients, doctors and managers and therefore their needs concerning Barco's products. Moreover, legislation might change, other interesting markets might emerge and competitors might take the competitive advantage.

What is the most profitable, most viable and most sustainable future for Barco in this changing landscape? A company like Barco cannot simply change to get to this future. There might be a need to collaborate between departments, collaborate with other companies, different jobs, change of processes. These changes all have their own timings and relevance and they should be defined carefully beforehand.

When plans and processes are created for the 'near' future (one or two years), Barco managers and employees can execute these. It is different when these plans must be made for a longer term. This is because over longer periods of time things can change drastically. What was once created out of a certain vision can now be completely different because there are different employees/managers working on the project or the context has changed. This creates the need for a visually comprehensive overview of the future. Not only does this need to be communicated to the top-management level, but also to the relevant departments and stakeholders. In summary: For Barco to be at their full potential they will need to plan their future carefully and be able to communicate that to all relevant stakeholders.

When planning for further in the future than a year or two a roadmap helps in communicating the essence of a project, department or even an organisation. As defined by Simonse in 2017: "In essence, a design roadmap offers a tactical plan on design innovations to turn a future vision into a reality." It can provide a quick overview of the general plans, addressed values and overall strategy for people that are not yet involved. Besides creating an overview, a roadmap supports the innovation strategy of an organisation (Simonse, 2017).

In this thesis, the method of Design Roadmapping is followed for the Diagnostic Imaging business unit. Creative trend research is conducted, including desk research and user interviews. The future values of the users (radiologists) are mapped in the value mapping stage, resulting in a future vision. With this future vision in mind, relevant technologies are scouted and a time pacing strategy is conducted. All of these elements are combined in an idea mapping session. This session is the basis for the product/service layer of the roadmap and concludes the idea mapping phase. This phase yields a Design Roadmap, the end product of this thesis.

Contents

Context analysis

Before the roadmapping process is explained there needs to be a basic understanding of the healthcare market, Barco's position in it and some other company characteristics. This is explored in the context analysis and is divided into four parts: Introduction to healthcare, Internal analysis, External analysis and Synthesis. The introduction to healthcare describes general characteristics of the market and the most relevant developments that are happening at this moment. The internal analysis describes the healthcare department of Barco, their products and a separate part with their innovation strategy. The external analysis gives an overview of the healthcare market in general and describes the sales channels as well as their competitors. The synthesis combines these parts by giving a summary of the learnings. Additionally, the synthesis provides an overview that gives direction to the remainder of the project. This chapter, the context analysis, will focus on the present state of the healthcare market and Barco as an organization. After this chapter, the method of design roadmapping is explained.

Introduction to healthcare

First, a short overview of the healthcare market is given with the most important insights for Barco. Then, the four most relevant developments that are happening in the healthcare market up until now are explained.

General introduction to healthcare

The healthcare market is different from a traditional supply and demand market. The biggest differences are:

- There are a few parties that have their role between the supplier (healthcare product provider) and the demander (patient)
- The market is heavily controlled by regulations and approvals
- The value that is exchanged is directly linked to health of people. This creates an ethically sceptic mist over every innovation that is done in this market.

Hospitals are clustering nationally to improve the skills of the doctors. This happens in all of Europe. In each of the clusters the hospitals are responsible for a different part of the body (e.g. Lung, Liver, Bones). This way, the care professionals specialize themselves in everything regarding that part of the body, ultimately increasing quality and even efficiency. A hospital cluster compared to hospitals is the same as the EU countries compared to Europe. They work together but they are still competing to get the best economic advantage. Every hospital wants to be the biggest hospital with the most patients (M. Massart, personal communication, 15-05-2019). This project focuses solely on Europe for complexity reasons. Even though it is the same continent, the funding for healthcare in Europe is taken care of in very different ways as can be seen in figure 1. This figure shows that there is no one-fits-all strategy because of the fragmented responsibility. Apart from responsibility, the value of the products and services in the healthcare market is determined by the care professionals or committees in the hospital. These professionals therefore determine the value of Barco products and will be regarded the target group.

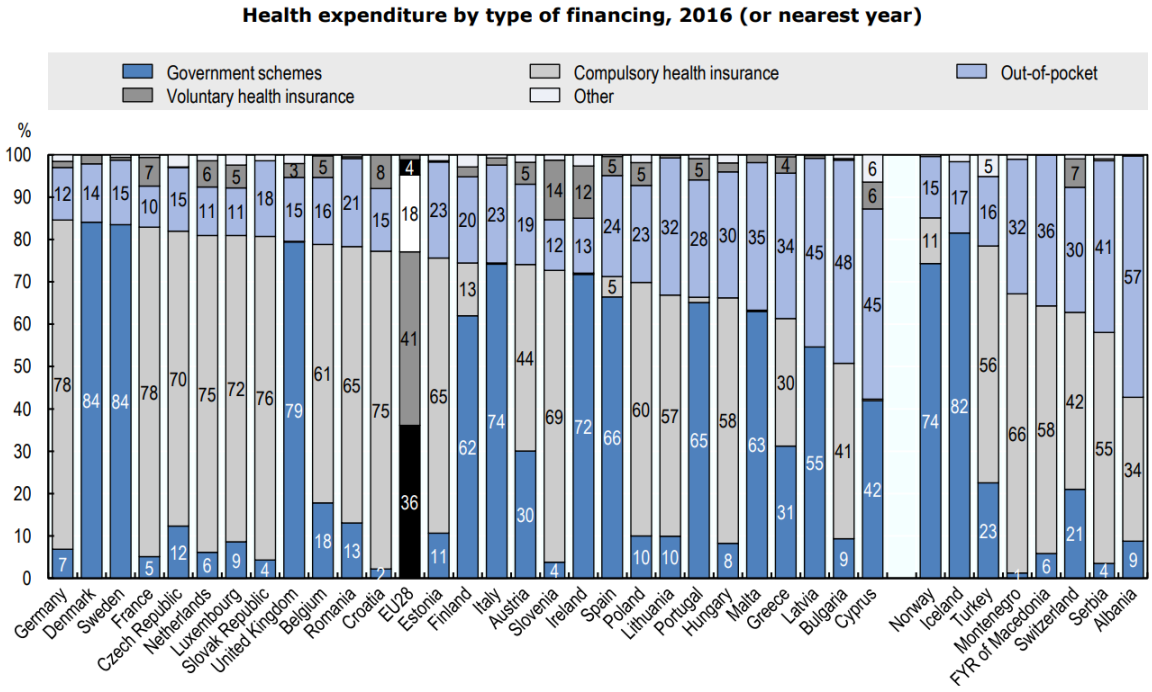


Figure 1 - Health expenditure by type of financing ("Healthcare expenditure statistics", 2018)

Introduction to radiology

"A radiologist is a medical doctor who specializes in diagnosing and treating disease and injury, using medical imaging techniques such as x-rays, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine, positron emission tomography (PET), fusion imaging, and ultrasound. Because some of these imaging techniques involve the use of radiation and require training to understand radiation safety and protection" (RSNA, n.d.). As this project revolves around the diagnostic imaging business unit, radiologists will be considered the key-users of the products of Barco. This part explores the hierarchical construction in hospitals and the position of radiologists in this hierarchy.

There is a huge difference between general hospitals and university hospitals in the way radiologists are employed. In general hospitals, radiologists make the decision themselves as to what devices they need to do their work properly. Radiologists here are organized in partnerships where they determine their own income and are responsible for the acquisition of new devices in the department. There is no general manager in between the radiologists and the hospital so that decisions can be made faster. The decision-making sequence for when a large purchase is made will be as follows:

- Radiologist
- Head of service of radiology
- Purchase commission hospital
- Board of the hospital

Note that up until the purchase commission of the hospital everything regarding the specs of the product are made without consultation with the management. In many European countries the purchase of medical devices that cost above a certain amount of money need to be tendered by law. This means that the hospital puts out a request for the needed material and companies can offer them their options. This is done to increase competition between medical companies. At university hospitals there is a board that decides on these acquisitions where radiologists only have an advising role. Radiologists get paid by the hour and have no say in the amount of money they receive for the services they provide.

Most of this information is discussed in a phone call with Matthieu Massart, a director in the AZ Sint-Lucas hospital in Gent (M. Massart, personal communication, 15-5-2019).

From now on, radiologists will be regarded as the most important users in this project and their values and wishes will be explored elaborately in the value mapping phase.

Most relevant developments in healthcare

Finding the most relevant developments in the healthcare market was mostly done with information from papers and articles. Some of the insights come from interviews that were conducted in Barco or externally. The three developments that are most relevant to this project are addressed. These three developments are: Artificial Intelligence, Electronic Medical Records and Personalized care. Every development will be explained briefly in the following part. Artificial Intelligence will be explained more elaborately because of the complexity of the technology and the prominence in the medical field. First, a quick overview of how the developments relate to each other is given.

Ideally, all possible information of a patient is used in the care for that patient. This is called personalized medicine, where every patient is treated as an individual according to the information specific to them. This is a system where there are no general 'tracks' for patients to follow. To enable such a system, a lot of data from the patients is needed. To make such data accessible to the patient and care professionals there is a need for electronic medical records. This enables the patients to share their record with anyone while still being in control of their own data. These developments require a lot of extra processing and data transfer than the existing systems. Processing with Artificial intelligence is needed to realize the extra workload from medical records or to enable personalized medicine.

The three developments are elaborated upon in the following part.

Artificial Intelligence

This is more of an umbrella principle nowadays as Artificial Intelligence (AI) can be used in a variety of cases. AI is the term that is used to describe machines that mimic "cognitive" functions that humans associate with other human minds (Russell, 2009). The use of AI in the healthcare field will now be explained.

Machine Learning

It is known for quite some time that computers can be valuable in repetitive and well-defined tasks. More recently, it became apparent that computers are able to solve problems that were thought to be too complex to solve for a machine. In some cases, machines have proven to detect patterns that humans could not detect. This has led to an increase in interest in the field of machine learning (Erickson, 2017). The definition of Machine Learning (ML) comes from computer science and is defined as "Field of study that gives computers the ability to learn without being explicitly programmed" (Samuel, 1959). ML is something that is accepted slowly in the medical field. This may be due to the abundance of tools that is available to the physicians, with every tool creating more complexity in the process (Kononenko, 2001). A brief history of machine learning (ML); As soon as computers came into use in the 1950s and 196s, algorithms were developed that could be used for analysing large sets of data. From this point three branches of machine learning developed: Symbolic learning (Hunt, 1966), Statistical Methods (Nilsson, 1965) and Neural Networks (Rozenblatt, 1962). Symbolic learning is the term that is used for the collection of all methods that are based on the representation of problems that is readable by humans (Haugeland, 1989). Statistical methods are based on linear and quadratic functions and they describe reliable approximations of probabilities (Kononenko, 2007). Neural networks will be explained further in this thesis as they are the most widely researched and proven to yield high performance in recognising images.

Neural Networks

The application of neural networks is explained in several articles and papers. Neural networks refer to the networks of the human brain as it is modelled loosely in this way with several algorithms as can be seen in (figure 5). Research continued to explore the use of neural networks in healthcare in a controlled environment, where the outcomes of the calculations are already known (Boone, 1990; Wu, 1993; Lo, 1995; Kahn, 1994).

The first computer assisted diagnosis (CAD) in Mammography was done in 1998 (Giger, 2002). Hereafter, different methods of using neural networks were explored (Abbass, 2002) and neural networks were compared to more classical methods (Sargent, 2001; McLaren, 2009). More information and data were added to the algorithms to improve its accuracy when researchers specified the method of using neural networks when combining symptoms and images (Al-Shayea, 2011). However, the limitations of neural networks were explored as well when the training data is not presented in the right way (Mazurowski, 2008). The field continues to expand, in depth as well as in breadth.

Diagnosis and Workflow

Two major fields can be identified in which AI can be of value for the medical field. The implications of assisting with diagnosing through image recognition are already explained. The second use for AI is the assistance in the workflow of the radiologists. An example of this could be something called 'triage'. This refers to the ordering of treatments based on medical urgency. Simply put, the urgent cases are moved upward in the workflow so that these cases get more immediate attention. The use of triage came under

attention when researchers coded 514 images of patients with lung cancer (Lodwick, 1963). The codes make it quantifiable for the computer. Thus, the computer can learn what cases are more urgent than others. This only works when the cases are annotated correctly. This means that the diagnosis is proven to be true. This performs well when the computer is given a sample of 20.000 cases to train on and becomes better and better with more cases, as is argued by a researcher from the Radboud University in Nijmegen (van Ginneken, 2019).

The research area of triage has caught a lot of interest in the medical field. A massive survey was conducted among 270 French radiologists about their perceptions and expectations of AI in radiology. The highest expectations for this technology are the lowering of medical errors, the reducing of interpretation times and the increase of time spent with patients (Waymel, 2019). At this moment an even larger research about the expectations of AI is being conducted, worldwide (Ridley, 2019).

The application of AI technology raises the question: Will a radiologist be obsolete within a certain amount of time? Most researchers believe that this is something that will not happen, at least not in the foreseeable future. Machine learning will be used as any other tool that is available to doctors. The responsibility of the diagnosis will remain with the radiologist and not with the AI system (Harvey, 2018). Neural networks enable high performance diagnosis in one task, but in its current forms cannot replace the radiologist's role in detecting incidental findings and performing more complex cases. "This role for radiologists will continue to be invaluable in the era of worldwide population aging, as large numbers of elderly patients have multimorbidity" (Yasaka, 2018).

Electronic Medical Records

The digitization of medical records was proposed in the US. In 1997 researchers of the Institute of Medicine provided "The Computer-Based Patient Record: An Essential Technology for Health Care". This described the characteristics of such a record and made recommendations for the future (Dick, 1997). There are numerous benefits of the use of an Electronic Medical Record (EMR) or Electronic Health Record (EHR) over the traditional paper records; among various other benefits are accessibility and availability to patient data, reliable data integrity, usability and flexibility, supportive of multiple user views, possibility to integrate with other systems, fast performance and confidentiality (Iakovidis, 1998). Even though EMRs bring many benefits, they are far from being fully implemented. According to research among hospitals in the US, only 1.5% of U.S. hospitals have a comprehensive electronic-records system, a system that is present in all clinical units. Respondents cited that capital requirements and high maintenance costs are the main barriers for the implementation (Jha, 2009). This is however in the US and not in Europe. In Europe the implementation of such an EMR may prove to be difficult as Europe is divided into various countries with different cultures and leadership. The UK has adopted its own version of an EMR, the NHS Healthspace (Pagliari, 2007). At this very moment researchers are conducting pilots with hospitals across Europe in order to create a unified European EMR, EHR4CR (de Moor, 2015; Claerhout, 2019). This project could ultimately bring essential and safe medicines quickly to the market and medical research will be expanded and enriched (de Moor, 2015). One of the main reasons EMRs are not implemented all over Europe yet is incompatibility between different systems and databases, this remains a barrier to integrate records. Although this is expected to be resolved when data standards and new technology are adopted (Pagliari, 2007). Another reason for the delay of implementation is privacy of the patients, where perceived control and trust play a role (see figure 2). Blockchain technology could potentially be one of the most promising solutions to this problem as it is a technology that can provide an open and secure access to patient data (Zhang, 2018).

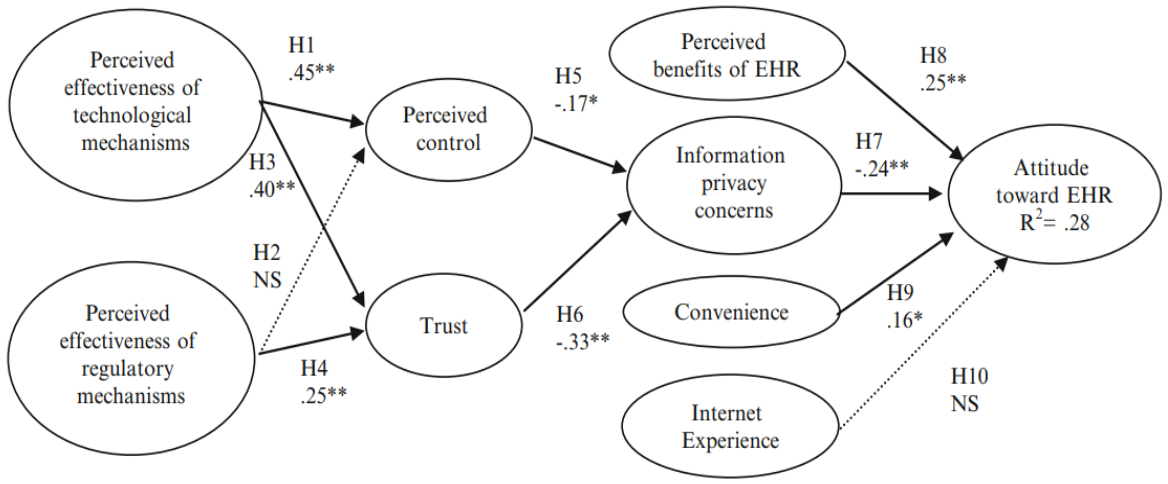


Figure 2 - Results of the tested model on attitudes towards EMRs (Dinev, 2016)

A study was conducted on the attitudes of individuals towards EMRs. The study concluded that the perceived effectiveness of technological mechanisms was the biggest determinant in influencing both the perceived control and the trust of the individuals (H1 and H3). The eventual attitude towards EHR is influenced most by the perceived benefits of the system (H8). All of the connections and influence factors can be seen in figure 2 (Dinev, 2016).

Personalized Care

With the increasing stream of data that is available from the patient and its genes, the need for healthcare that is tailored to the individual has followed (also see figure 3). Researchers redefined personalized healthcare as "A coordinated, strategic approach to patient care that broadly applies the concepts of systems biology and personalized, predictive, preventive and participatory care, and employs appropriate technologies to customize and deliver care across the health continuum from health promotion and prevention, to detection and treatment of disease" (Simmons, 2012). A simplification of personalized care, also referred to as precision medicine, is given in figure 3. Personalized medicine, diagnosis and treatment derived from the individual's molecular profile, will impact the way medicine is practiced (Ginsburg, 2001). This is not only true for the practice of healthcare but also the time and place of care as diseases can be addressed and prevented at the earliest possible moment (Zhang, 2005). To deliver personalized care, a Personal Healthcare Plan (PHC) plan is needed. This is a customized plan defined by the provider and patient that is used as an organizational tool to manage the treatment process for the individual (Simmons, 2011). Researchers are looking into the so-called 'digital-twin', a digital replica of a living or non-living entity (El Saddik, 2018). The digital twin can provide strong support in cloud healthcare services (Zhang, 2019). Health companies are already investing in using the digital twin for personalized healthcare purposes (Copley, 2018). However, there are barriers to the adoption of a personalized care system. To achieve personalized care, there is a need to integrate and assemble the data from a large number of patients (Ginsburg, 2011). This would mean that something similar to an EMR is needed to facilitate the assembly of the large dataset. Moreover, large amounts of algorithmic optimization and computational power are needed (Cirillo, 2019). The gap is widening between the rapid technological progress in data acquisition and the comparatively slow functional characterization of biomedical information that is needed in personalized medicine (Berger, 2013). Analysis and communication of the vast amounts of data are increasingly explored by scientists in genomics through cloud computing rather than doing this locally (Langmead, 2018).

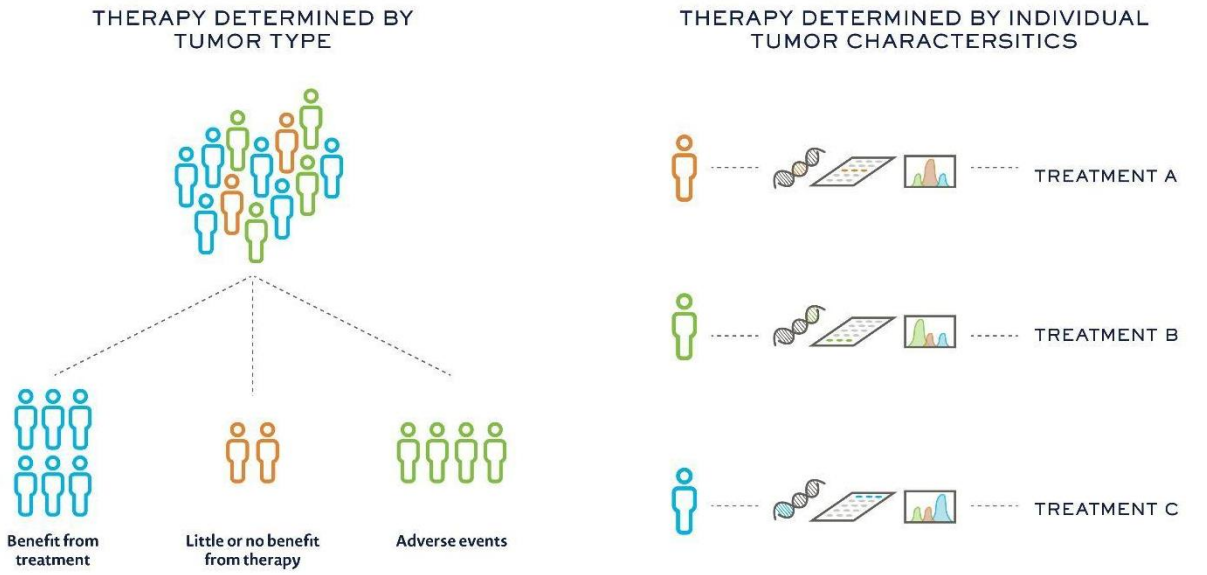


Figure 3 – Comparison of traditional care and personalized medicine (Precision Medicine, 2019).

Internal analysis

The healthcare department within Barco has a few different business units: Diagnostic Imaging (DI), Surgical Imaging (SI), Custom Modality (CM) and two incubators named 'Demetra' and 'Care Consultation'. Diagnostic Imaging is the business unit that is responsible for the products related to diagnosis. Surgical Imaging is the business unit that revolves around surgery assistance. Demetra is a capturing device that is used in dermatology and it is the most recent large development of Barco in healthcare. It is different to the rest of the portfolio in the sense that it is an end-to-end solution, a solution where Barco provides value in every step along the way (capturing, processing, visualizing, interaction) instead of being a part in a greater whole. Care Consultation is a platform where care professionals can collaborate in a multidisciplinary setting.

An overview of Barco Healthcare is illustrated in figure 4.

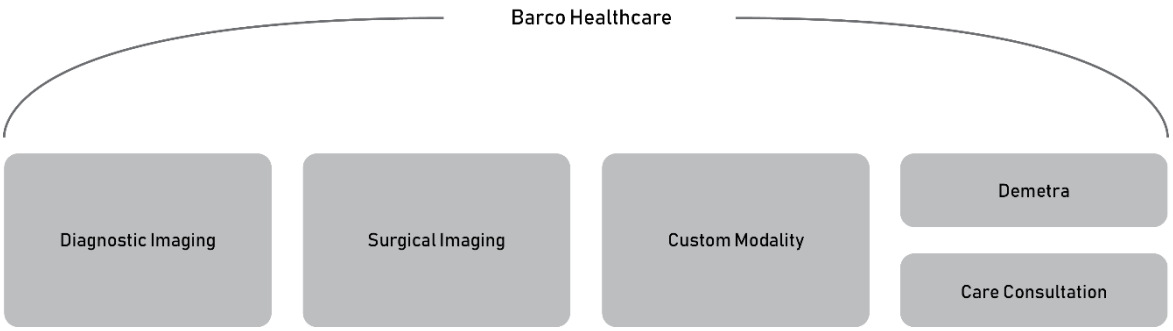


Figure 4 – Business Units of Barco healthcare

This project focuses on Diagnostic Imaging for time and complexity reasons. The DI portfolio consists of various screens for viewing, customized Graphical Processing Units (GPUs) to process the input of the scanner and QAWeb, quality assurance software. All of these products ensure the highest quality and efficiency when viewing images for diagnosis. Barco only has access to pixels in this segment as the capture devices or scanners (e.g. MRI, CT, Echo) are owned by other companies.

Radiologists are the most substantial group of users of Barco's DI products, thus they will be considered the end-users. Even though radiologists are the end-users, there are a lot of other professionals that have a deciding role in the hospital as can be seen in figure 5. For the value mapping phase, the values of the radiologists will determine the future vision. However, the needs of the other stakeholders will be regarded as well when making decisions.

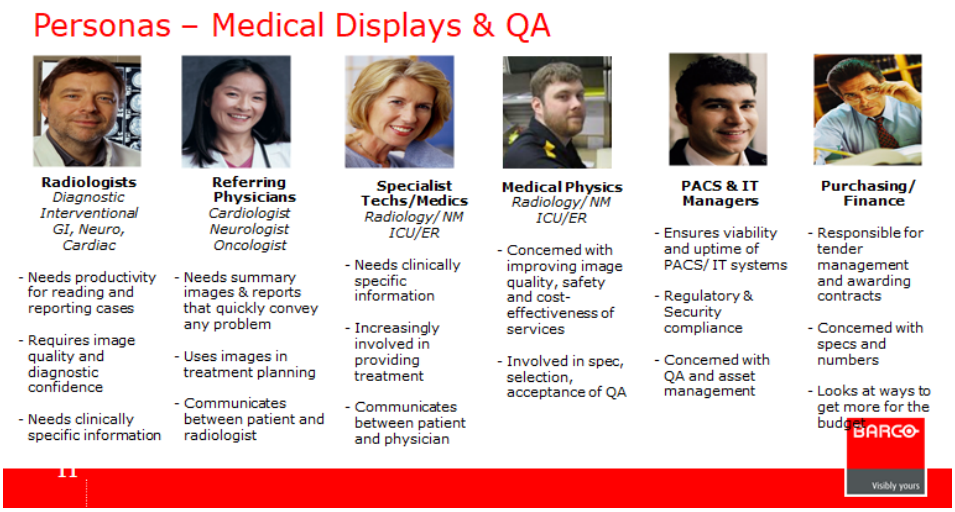


Figure 5 - Personas for the Medical Displays and Quality Assurance (Barco, 2015)

Innovation strategy

Decisions of the board are mostly based on operational expenses (OPEX) and cost reductions (R&D Manager & VP R&D Healthcare, personal communication, 3-4-2019). This makes it hard to look far into the future as it is hard to argue for expenses and investments that will benefit the company in the future. Barco has a yearly cycle called profit-plan. In this plan, the available resources and targets for the different business units are made.
For Barco to have a strong position in the market they need to develop products or services in four areas that are connected to each other. The four layers are referred to as the 'value stack' are shown in figure 6.

Ideally, Barco has products in every layer and the layers support each other. For example, radiology screens (Displaying), connected to each other and to computers (Connectivity), with software that helps the radiologist (Workflow), and the ability to analyse the usage of the screens (Analytics & Insights). The insights that are produced by the top layer can then be used to innovate in all of the other layers. In short: the value stack is a way for Barco to get to the end-user and to collect relevant data from them.

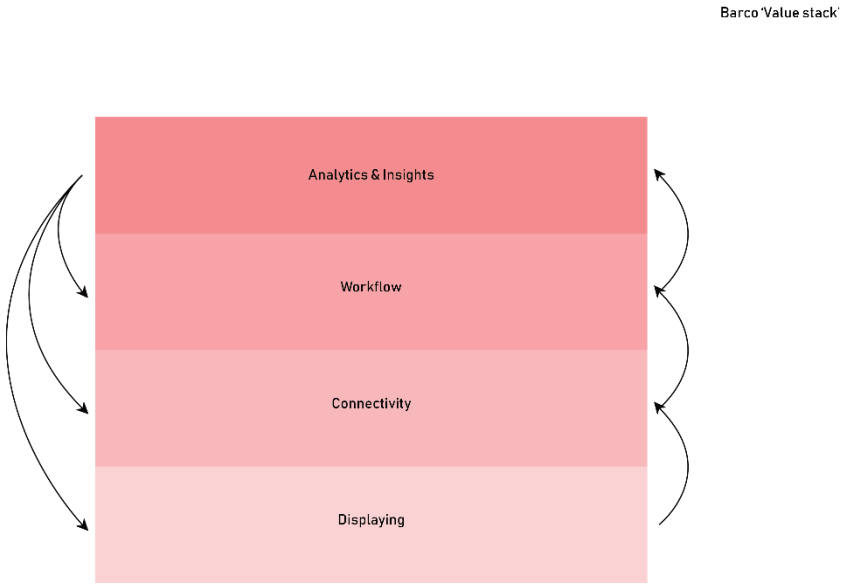


Figure 6 – Barco value stack

At this moment, the largest part of the monitors that are installed at hospitals and clinics are solely screens that have no connection to Barco anymore. This is something that Barco refers to as 'modality': nothing more than a monitor, a part in the whole without connection to the other parts. One of the missions is to make this modality business disappear by making the screens connected to Barco through providing processing and control software or software that assists in the workflow of the user.

General decision-making process

Healthcare management has meetings on which there are a few project options to start with. Specific criteria are thought of and the ideas are tested on these criteria. A small amount of these projects gets through this test and the chosen projects will be analysed on different aspects to determine the viability. The executive committee (ExCom) then decides if the projects will be accepted or not. If accepted, the proposition will go to the CEO to decide if the needed amount of money is there to facilitate the decisions. The proposed project can be altered in order to get to this point. After the CEO decides, the idea goes to the board of directors who have the final say in what happens with the proposal.

Every year a series of meeting is planned to determine the strategic direction for the future. This planning into the future is called the Strategic Marketing Plan (SMP) and the scope for this plan is around 3 to 5 years. For these meetings the different business units prepare cases to make an argument for receiving the funds to embark on a project. During these meetings the investments, potential return, risk, fit with company etc. are assessed. This process is still for the most part based on gut feeling and is not quantified. The experience of the people that work in the business units is the main determinant if a project gets funded (Barco meeting, internal communication, 28-3-2019).

Before one of these meetings, the most viable options are prepared by the business units. Most of the times, thorough brainstorming and some numbers are the determinants to get to possible ideas. For when looking in the future for further than 18 months, the process is not defined and things are regarded as future 'stories', as they are hard to validate. The validation for these closer projects consists of the fit with strategic and tactical points that are predetermined. There is a committee within Barco that determines the value a project would bring to customers compared to the costs of the project, this is called value engineering. The Concept Value Review (CVR) is something that is used and consists mostly of a survey. This happens exclusively when testing the user experience of a product. Take note that this kind of user-experience test is obligatory by law in the healthcare market. Interviews and more personal research to assess the desirability of a product or service is not conducted. Testing their products early on is seldom done as Barco is scared that the competition will notice.

Diagnostic Imaging market

The DI market has been "milked enough". Too much of the resources that were earned through diagnostic displays are put to other use than DI improvements. The market of for example mammography has reached its top. But this doesn't mean that there is no money to earn in this market. For the coming 5 to 10 years there is a need for incremental innovations. When asked about the changing role of the radiologist the Senior Product Manager of Diagnostic Imaging mentioned: "Radiologists are not getting out of their jobs, it will simply change the way they work" (Sr. Product Manager, personal communication, 22-3-2019). It is believed that diagnosis done without the radiologist is something that may happen in a decade or more rather than years (Vice President Technology and Innovation, personal communication, 22-3-2019). For the coming years there is a project to apply AI assistance in existing screens. This is done in collaboration with developers from 'Screenpoint' who have software named 'Transpara'. These are not unknown developers because they developed the software side of the digitalisation of mammography a few years ago. Barco had a first mover position in the mammography market as the software and hardware together determined the quality that the viewing experience should have (VP Diagnostic Imaging, personal meeting, 11-4-2019). Barco spends a lot of resources to get things regulated and checked by the FDA to be the first movers in a field (R&D Manager & VP R&D Healthcare, personal communication, 3-4-2019).
There is room in other segments for the DI business like in pathology, dental and ophthalmology (VP Diagnostic Imaging, personal meeting, 11-4-2019). There are no channel conflicts when implementing an end-to-end solution in one of these segments (Company mentor & VP Diagnostic Imaging & Vice President Technology and Innovation, personal meeting, 9-4-2019). Barco has a focus on end-to-end solutions to be able to own the complete cycle from the moment of content creation to the interaction of the user (Company mentor & VP Diagnostic Imaging, personal meeting, 10-4-2019; R&D Manager & VP R&D Healthcare, personal communication, 3-4-2019. First, this enables Barco to gather data from every link in the cycle and thus the ability to improve their products and services. Second, this makes them less dependent on their channel partners. Third, to get a user value perspective, more grip on what the users want instead of middle men (Vice President, Care Consultation, personal communication, 11-4-2019).

The 'elephant in the room' in the healthcare department is the dilemma: Either invest in the existing DI portfolio and make incremental innovations there or fund new incubators that have potential to grow but that may take a long time (Vice President, Care Consultation, personal communication, 11-4-2019).

External analysis

Barco does not sell their products directly to hospitals as their products are always used in combination with another device. The contact of Barco is never with end-users but always with IT professionals from the healthcare market or other professionals that are responsible for buying hospital equipment. This means that the link to the end-user is not present (; R&D Manager & VP R&D Healthcare, personal communication, 3-4-2019).

The main customers of Barco are Original Equipment Manufacturers (OEM), System Integrators (SI) and Resellers (adding a value or not). These partners are further explained in figure 7. This figure is created with the help of two managers in healthcare (Manager Channel Development and Strategic Programs, personal communication, 8-5-2019; Segment Director EMEA Diagnostic Imaging & Modality, personal communication, 9-5-2019).

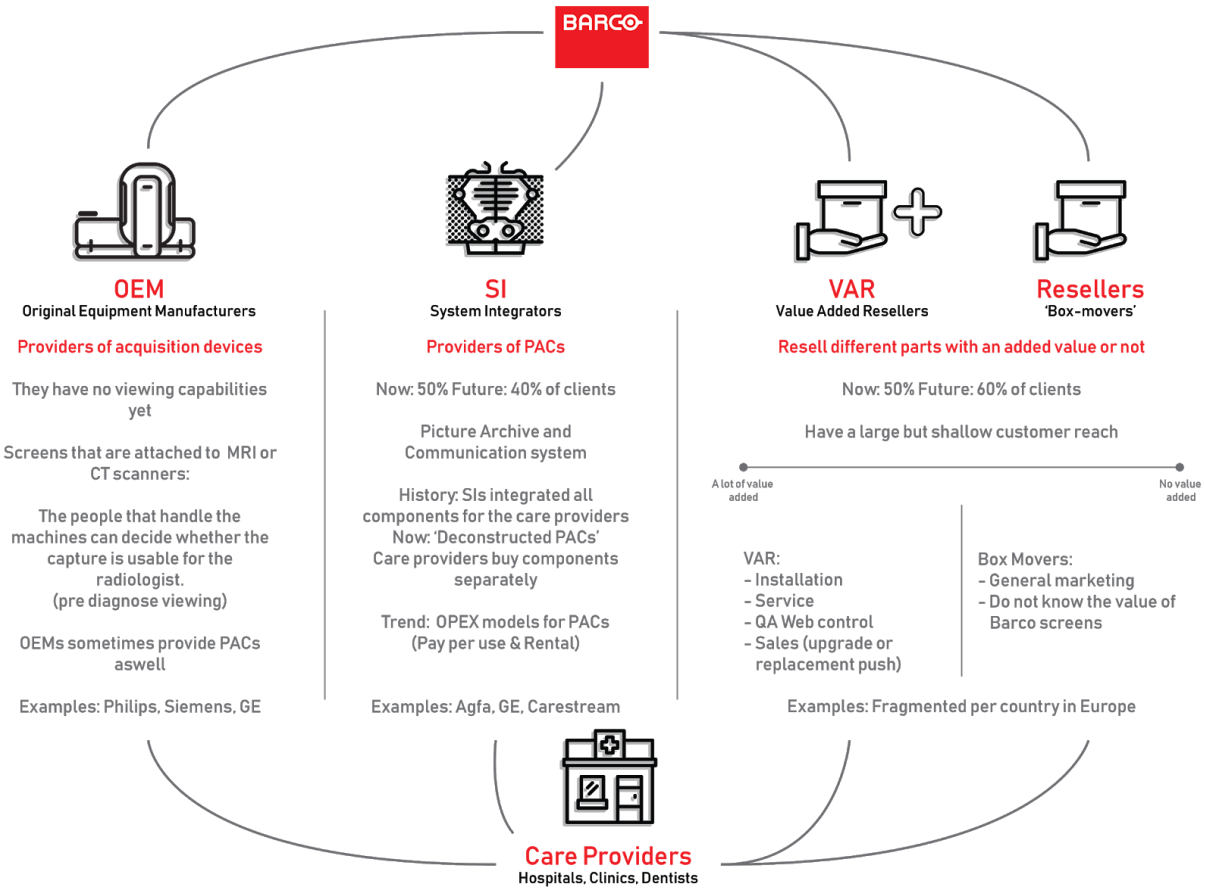


Figure 7 - Representation of different channel partners in Diagnostic Imaging

The system integrators used to combine all of the different elements for the hospitals (e.g. scanners, systems, database and screens) This is due to the fact that hospitals did not have the expertise to make these decisions. Nowadays, hospitals increasingly have specialized IT departments that are able to integrate the systems themselves (Manager Channel Development and Strategic Programs, personal communication, 8-5-2019). For this reason, Barco is selling more products to the resellers than the OEMs and SIs since 2018. This can be seen in figure 8. This creates a stronger decision-making position for the hospitals and thus the radiologists.

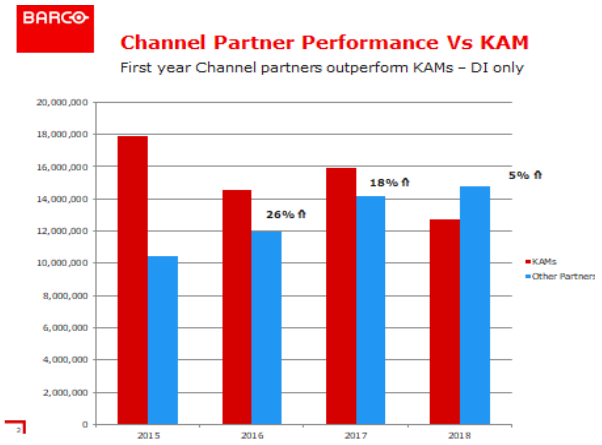


Figure 8 - Sales of channels in the DI market (Barco, 2018)

Barco has a niche position in the market and they only control a part of the 'content value cycle'. To be able to innovate in the healthcare market Barco needs to find an area where they will not compete with their channel partners. Their partners have the power to end contracts when they get competition from a company like Barco. For example: If Barco would make a scanning device with a screen attached for mammography, companies like Philips or GE that make these scanning devices will simply end the contract with Barco and look for a different provider for their screens.

Competitors

As was mentioned in the internal analysis, the DI market has been under pressure because of low investments and increasing competition. Their main competitors are Eizo, JVC Totoku, Jusha, Beacon, Wide/Double back and LG (Product Manager Diagnostic Imaging Displays, personal communication, 13-8-2019). The diagnostic display quality is nearing a ceiling as the human eye will become the determinant of the quality, and not the screen itself. Consumer grade displays are getting close to the quality of medical grade displays. That is the reason why a share of the market is owned by consumer monitor brands like LG (Vice President Technology and Innovation, personal communication, 25-7-2019). The biggest competitor of Barco in the European market is Eizo, a Japanese company that has a similar portfolio to that of Barco. The respective market shares of the two companies and others is given in figure 9. In the top-left graph it becomes clear that the biggest global competitor for DI is Eizo. On the bottom-right it becomes clear that in EMEA (Europe, Middle-East and Africa) the market shares are even more polarized with Barco and Eizo making up around 90% of the market.

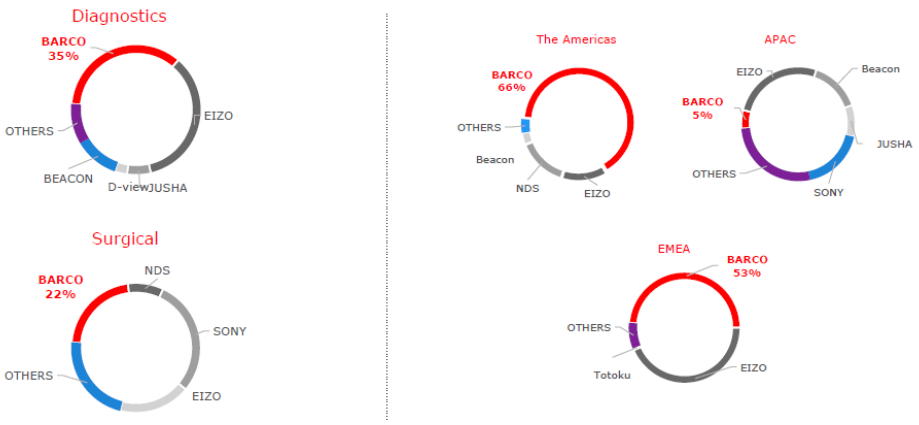


Figure 9 – Market shares of medical display companies per display type and per market (Barco, 2018)

Synthesis

After exploring Barco and the market they operate in, important conclusions can be drawn regarding the strategic direction. A summary of the findings and the integration of the separate analyses is given in the following part followed by the aim for the research.

The increased productivity and quality that AI brings and the increase in available data that the EMR systems bring will facilitate a growth in personalized healthcare, where as much relevant data as possible is used in the prevention, diagnosis and treatment of patients. The amount of information that needs processing per patiënt will grow with these developments creating demand for diagnosis based on images. The role of the radiologist is expected to change drastically.

As is stated before, radiology is increasingly supported by artificial intelligence in making diagnoses and determining workflow. There are a lot of companies and startups that create algorithms and software for this purpose. Barco has no interest in designing their own AI algorithms for detection of medical anomalies. However, it is imperative that Barco keeps innovating and adapting according to the changing working environment.

Diagnostic Imaging

Barco chooses to focus on end-to-end solutions to be able to collect data from every link in the cycle and to get the user value perspective. This is fueled by the increasing use of patient data. There is currently no end-to-end solution by Barco in radiology because of channel conflicts. There is room for end-to-end solutions in the dental market, pathology and ophthalmology. These areas may yield future profits but their existing DI portfolio, that consists mostly of the diagnostic displays for radiologists, has to stay up-to-date as well. When looking at the value stack (see figure 6), Barco needs to innovate more in the upper layers and move away from the 'modality business' as their only form of business.

In conclusion: there is a need for incremental innovation in Diagnostic Imaging in the short term as well as more radical innovation in the form of an end-to-end solutions for the longer term.

Figure 10 highlights the area where DI approximately is at the moment compared with a full end-to-end spectrum. Barco could expand their portfolio by creating products or services that involve more than visualizing like moving more towards either Process & Control or Interaction. In their current portfolio there is room for innovation in these areas, albeit incremental. For the more radical innovations, Barco could even innovate in the Content Creation quadrant like they did with Demetra.

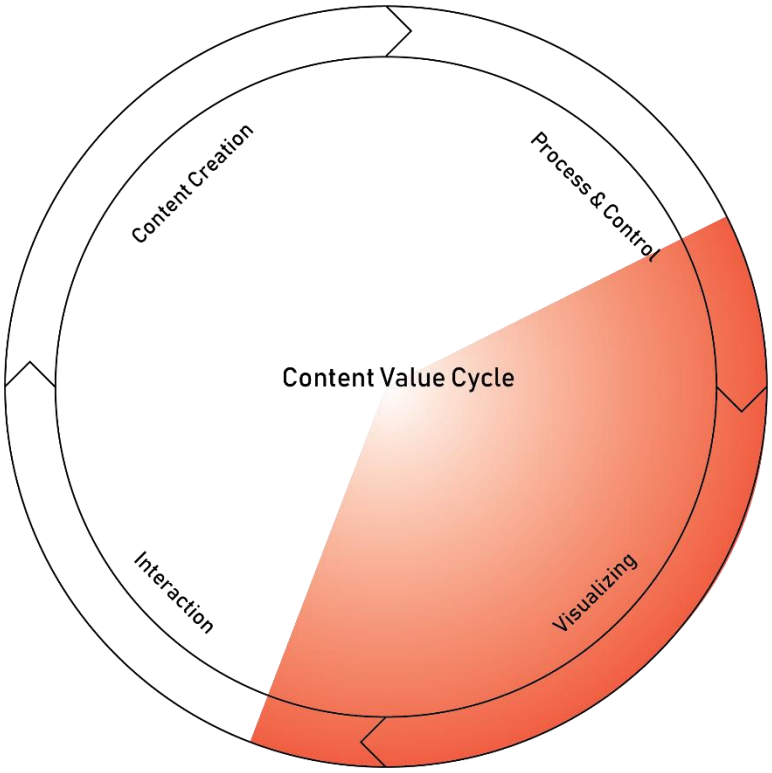


Figure 10 – Current DI portfolio visualized in the CVC

Early confirmation

Barco needs to test with users early in the process for desirability and viability, especially in the rapidly changing healthcare environment. For continuous feedback from products and services there is a need to collect user data. This feedback can then be used for the improvement of current products or facilitate the design of new products. Moreover, the more data is collected, the better personalized care can be facilitated.

There is a possibility to quantify the variables that are used in strategic decisions (risk, ROI, Barco fit, Portfolio fit, etc.). This would be a way to quantify Barco's ambitions, a way to use data-driven design in strategic decision making. Additionally, the process will be repeatable and can be built-upon. In the case of a project failing, Barco would be able to learn from the project.

Project direction

The general strategic direction for Barco is clear and a few points of interest and hurdles can be seen. When going into the specifics though, a lot of questions remain unanswered: What is the future of radiology? How does the role of the radiologist change? Is the radiologist still the most important user? And if not, who is? What does this mean for the diagnosis based on images? And most importantly: how does Barco adapt its strategy accordingly?

The aim of this thesis is to answer these questions by uncovering the desired future for Barco and determining the strategy in between. The first half of this project will be focused on determining the future according to the market and the user, gaining an outside-in view. The method of finding the desired future is explained in the following chapter: 'Roadmapping method'. The second half of the project will be focused on making the fit between Barco and this outside world. In the resulting roadmap, Barco's innovations will need to capture more from the content value cycle (provide interaction or process and control). Additionally, there have to be moments where desirability and viability are tested before the launch of an innovation.

At this moment there is no connection to the radiologist and there no data link from the user to Barco. This will need to change in order to facilitate the higher levels of the value stack (analytics & insight and workflow). The roadmap ideally incorporates innovations where the full value stack is used in the value proposition.

The roadmap is made for a mixed audience. On the one side for product managers and segment marketeers. The roadmap will function as a strategic tool that creatively expresses how Barco's products and services should work towards the future. On the other side, this roadmap is for the R&D teams and the engineers. The map shows how certain technologies and innovations can add value for the target group. Additionally, it shows when these technologies become relevant and how the innovations relate to each other to form a whole value proposition.

Roadmapping Method

For this project the choice has been made to use the method of Design Roadmapping. Design roadmapping is different from 'technology roadmapping' or 'product roadmapping' as it is not dependent on technology or company portfolio but dependent on the values of the end-user. The roadmap will give strategic insight as to what the desired future will be for the Diagnostic Imaging market where Barco operates and how the path to this future is walked. The first half of the project is dedicated to 'value mapping'. Value mapping contains 'creative trend research', which will be accompanied by interviews with end-users and experts. According to this input, a future vision was made in the 'future visioning' part of value mapping. This happened in a repetitive manner where a future vision was formed multiple times in between before the final future vision was formulated. After this, relevant technologies that can facilitate this future will be researched in the 'technology scouting' and the timing of innovations will be determined in the 'time pacing' phase. With technologies and timing factors defined, the mapping of ideas could begin in the mapping sessions. In these sessions ideas were formulated that evolved into the innovations on the roadmap. Together these activities form the phase of 'idea mapping', this phase concludes in a design roadmap. An overview of the methodology can be seen below in figure 11.

There is more value in this project than solely the results from the design roadmapping method. Firstly, the relevance of this method will be explored for Barco. The process could possibly be repeated by other business units. If so, what people and resources are needed to realize this and how should it be executed? These questions will be answered, at least partially, after the idea mapping results in the recommendations.

Secondly, the fit of an organization like Barco with the method has to be determined as well. Two large contextual factors may cause incompatibility between the organization and design roadmapping. The healthcare market or the business to business model might be of large influence to the effectiveness of the method. This is discussed in the recommendations after the idea mapping results as well.

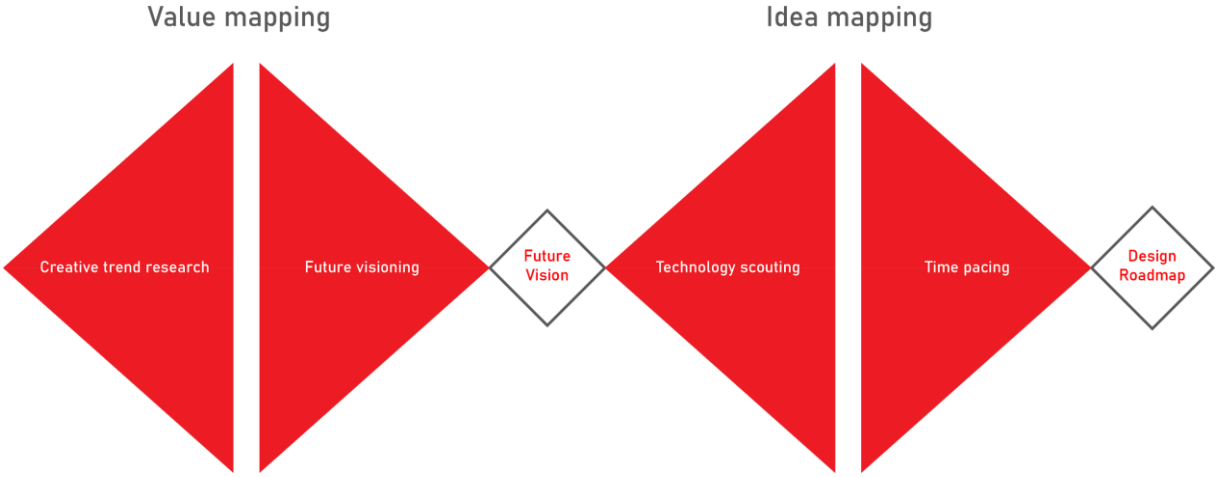


Figure 11 – Overview of the general methodology

Roadmapping metaphor

The method of design roadmapping suggests that there is a journey with an end-point and a certain way in which this is reached. To make this thesis easier and more interesting to follow, the metaphor of a real roadmap is used. When making a roadmap, there are a couple of elements that are crucial for reaching the goal. All of these elements relate to an exercise from the book Design roadmapping, they are explained below.

Defining the destination

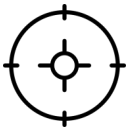
The first phase of the project is dedicated to defining the destination. Defining the goal of the journey is the most important and therefore half of the project is dedicated to this phase. This is directly comparable to the value mapping phase in the roadmapping method. This can be separated in 'Exploring destinations' and 'Choosing a destination'.

- Exploring destinations

  When exploring destinations it is important to keep a broad scope, find as much information as possible about as many destinations as possible. This phase relates directly to 'creative trend research' in the roadmapping method.

- Choosing a destination

  After the exploration of possible destinations, a choice has to be made as to what destination is chosen to be the end-point of the journey. The choice of a destination is directly related to 'future visioning'



Preparing for the journey

When preparing for the journey, there are three important steps that have to be taken: determining the tools for on the road, time planning and what vehicles to use. These all make up the idea mapping phase from the roadmapping method and are explained in more detail below.

- Tools for on the road

  Tools for on the road includes 'technology scouting'. Here, relevant tools (technologies) are defined that can be of use to reach the destination.

- Time planning

  When embarking on a journey it is important to plan the steps wisely. Time planning relates to 'time pacing' from the roadmapping book. After these steps there is one more step needed to get to the destination, vehicles.

- Vehicles

  Without the appropriate vehicles, the destination will not be reached. These vehicles are dependent on the tools for on the road and the time planning. Defining the vehicles is directly related to the mapping sessions from the roadmapping book and it concludes the idea mapping phase.

With these elements defined, the roadmap can be made. All of the elements should be appropriate for the job in order to reach the end-point of the roadmap, the destination.

The following chapter is named 'Defining the destination'. What are possible end-points for the journey? How to choose between these? Which destination will be chosen? These questions will be explored in this chapter.

Defining the destination

Possible destinations of the roadmap, the selection and the final destination are discussed in this chapter. Defining the destination is directly related to value mapping, the first phase from the roadmapping book. It concludes with the chosen destination and goal of the roadmap.

This chapter starts with the explanation of the methods of creative trend research and future visioning. Followed by the results of the value mapping phase and concluding in the future vision.

Before the method is explored, there are a few terms that need to be defined carefully beforehand.

Value mapping is the process where trends are defined that create potential value in the future, after this the trends are accumulated into a vision. Before the method is further described, the terms 'value', 'value wish' and 'trend' are defined carefully.

The word 'value' has various definitions. The definition that will be used in this thesis is one that lies closest to the definition of value that is used in the roadmapping book (Simonse, 2017). Even though no exact definition of value is given, the definition can be derived from the examples that are stated in the book. Examples are: 'Safety', 'Overview' or 'Trust' among others. The definition of value that will be used in this thesis is comparable to that of the roadmapping book. A value describes a distinctive characteristic of a process or an activity that is valued by the user. Values are time dependant as they can change over the years and differ between generations.

Closely connected to the word value is 'value wish'. "A value wish expresses a desired end-state in which a novel value fulfills an unmet need or resolves a present dilemma or feeling of frustration experienced by a user target group" (Simonse, 2017).

The evolving definition of trend is given in the book by Simonse according to the Oxford dictionary (Simonse, 2017). Four versions of the definition are considered together for the remainder of the book. All of these definitions have one thing in common; they all refer to a state that is changing or has changed since the past. The 'trend' is the descriptor of the direction in which something is changing. The definition according to the Cambridge dictionary: "a general development or change in a situation or in the way that people are behaving" ("trend", n.d.). This is the definition that will be used for the remainder of this thesis.

New value opportunities from trends and technologies into the future can be identified. A few of these 'value drivers' will be used to underpin the vision of Barco. Product of the value mapping stage is the future vision statement that is grounded in these value drivers (Simonse, 2017).

The value mapping process begins with creative trend research, the gathered insights from this phase will then be formed into a future vision. Both these processes are explained below.

Exploring destinations

When looking for a destination, it is important to select the best between various options. This part of the chapter is dedicated to exploring various destinations of the journey. Exploring destinations is directly related to creative trend research from the roadmapping book.

A specific technique of creative trend research is chosen for this project. This technique is discussed in detail below.

Trend patterns

This technique is described in the Roadmapping book. It is one of the four suggested techniques in creative trend research (Simonse, 2017). There were two techniques that are based on visuals. As visual cues are less important in the healthcare technology market the choice was made to make use of one of the other two techniques. The remaining techniques are trend scenarios and patterns. Scenarios would be a viable option, but in this process 4 extremes are created. I discussed with my chair and mentor that in this project it is better to create one future instead of multiple. This is because of time reasons and because I will express a desired future for Barco instead of a future determined by an extreme.

The trend patterns technique consists of two distinct activities: 'Immersion' and 'Create Patterns'.

In the Immersion phase the researcher first maps the area of interest with the stakeholders. This will result in a more extensive understanding of the subject at hand. What follows is desk research and interviews. The desk research comprises of reading relevant books, articles and internet pages. The interviews are done with both end-user and experts on the matter. The next step in the process is to make a 'watch list' of social media accounts, blogs, events, experts etc. In this way, initial clues can be triangulated and it becomes clear what the 'opinion leaders' or experts are dealing with. It is still to be determined how much of an influence these people will have on the medical imaging market. I will observe these opinion leaders and use Google alerts to notify me when articles related to healthcare are published. All of the insights will be documented carefully for later use in the process.

In the Create Patterns phase all of the information gathered in the Immersion phase is laid out in front of the trend research team. This team consists of the head researcher (me) and two graduating students that have experience with doing basic trend research. The team will try and uncover patterns in the information and the information will be clustered accordingly. The patterns will then be evaluated with other bits of information, statistical data and they can be used as conversation material in the interviews.

In the first weeks a list is formed of the sources that are going to be used for the rest of the project to come. This list will expand as the project progresses. In the interviews to come, the interviewees are asked about what sources influence them. The mentioned 'influencers' will then be added to the watchlist. The results of this trend research technique will be discussed with lead-users and thought leaders in the domain. Ultimately, this research uncovers future value drivers. These drivers will then form a solid basis for the creation of a future vision.

This method had been discussed with and supplemented by Hanne Caspersen, an expert in the trend patterns method (H. Caspersen, personal communication, 22-4-2019).

A simplification of the method for creative trend research is given in figure 12.

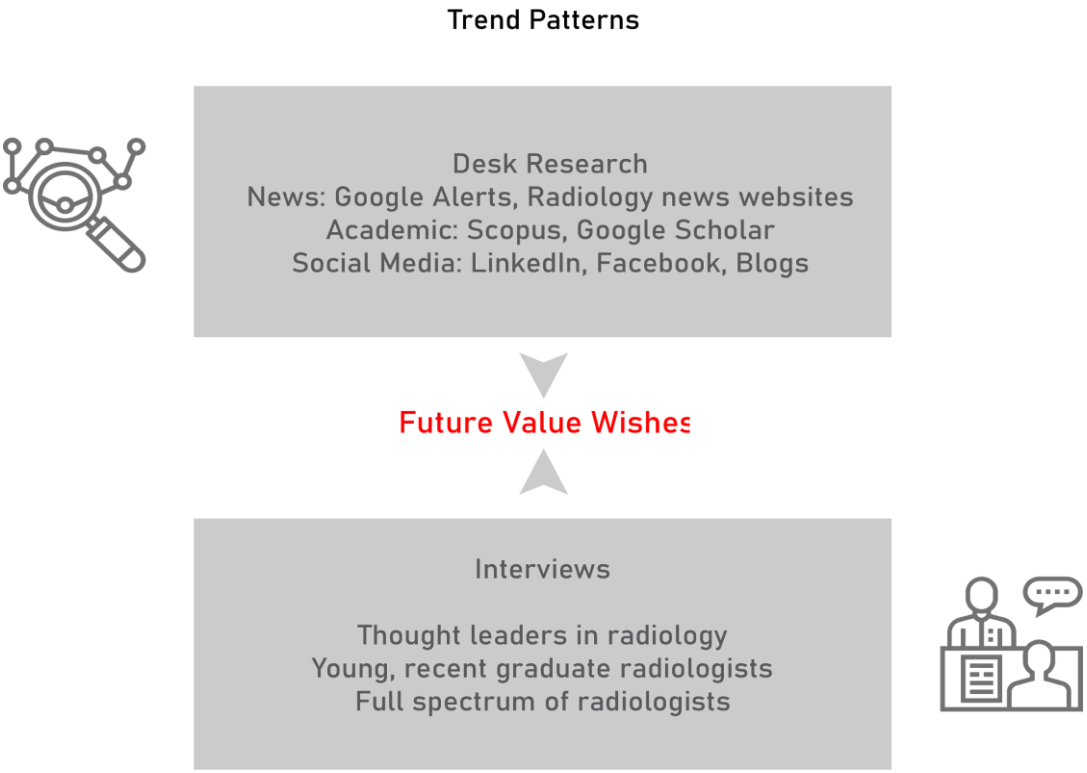


Figure 12 – Trend patterns immersion

List of sources

A variety of sources will be used for the trend patterns method throughout the project and this will expand gradually. Below is a categorized list of all the sources used per type of source.

News

- Google News: Radiology
- Google Alerts: Radiology OR Diagnostic Imaging
- AuntMinnieEurope
- RadiologyInfo.org

Social Media

- Spotify podcasts: RadCast, Radiology Podcasts RSNA, Philips Healthcare Talks,
- Radiology Cafe Blogs
- Facebook: Mayo Clinic, Diagnostic Imaging, AuntMinnie, AuntMinnieEurope, European Radiology, myESR.
- LinkedIn: Erik Ranschaert, Paul Algra, Lennart Blomqvist, Rizwan Malik..

Academic

- Scopus: query (radiology OR radiologist OR diagnostic imaging AND future OR developments)
- Google Alerts: Radiology OR Diagnostic Imaging

Interviews

There are two main goals for the interviews aside from immersion in the target group and context:

- Uncover future value wishes
- Insights in trends that are currently shaping the radiology field

The method for interviewing is part of experiential qualitative research, as the research aims to look from the user's perspective or experience (Braun, 2013). In this case the end-users are radiologists, which will be observed if possible and submitted to a semi-structured interview. "In a typical semi-structured interview the researcher has a list of questions or series of topics they want to cover in the interview, an interview guide, but there is flexibility in how and when the questions are put and how the interviewee can respond" (Edwards, 2013).

A general invitation email for the interviews has been made in a specific order, following the structure of 'The mom test' (Fitzpatrick, 2014). This possibly increased the chance of a positive reaction to the request. The invitation email message can be found in Appendix B.

In order to prepare for the interviews, three experts are interviewed:

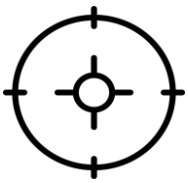
- Hanne Caspersen, an expert in the trend patterns technique.
- Elizabeth (Liz) Sanders, an expert in co-creating the future with users and co-author of Convivial Toolbox (Sanders, 2016).
- Pieter-Jan Stappers, similar as Liz he is experienced in co-creation and co-author of Convivial Toolbox.

With the help of these experts and internet research I was able to define an elaborate interviewing guide. It was used before, during and after most of the interviews. The guide describes the method used for sampling and the steps that were taken before the interview. Additionally, tips and guidance for interviewing about the past, present and future are stated. Altogether, it is a huge amount of information that is not necessarily needed to follow the rest of this thesis. For this reason the entire guide is placed in Appendix A. The topic list and the further analysis of the interviews are explained below.

Topic list

- Explain a day
    - Pick one day (take the day before)
    - was there anything unusual?
    - Draw a timeline
- Based on the description: Change in workflow since start of profession?
- Other changes?
    - People to work with
    - Systems to use
    - Contact with patient
    - Management
    - Etc.
- How was that?
- Why did those changes happen?
    - Certain need Radiologist
    - Need patients?
    - Hospital needs?
- Changes that are happening now?
    - Why?
    - Where do they come from? (what needs/values)
- Jump to future, how will your work change in 6 years?
    - Workflow?
    - Colleagues?
    - Communicating with others?
    - Contact with patient?
    - Management?
- Topic that came up from the observations
- Anything to add that wasn't discussed? (Patton, 2002)

The interviews were all recorded so they could be revisited afterwards. Because of time constraints, the recordings were only transcribed for the parts that have relevance for the project. The recordings were played back carefully and every part where the interview goes off topic was left out. This sped up the process of the analysis, while keeping the complete depth of the interview. This is not described in a specific method; rather it is a technique that is a simplification of grounded theory (Birks, 2015).



Choosing a destination

When the search for destinations does not effectively yield additional results, the time has come to make a selection. This happens in a coordinated and argued manner. Choosing a destination relates directly to future visioning from the roadmapping book.

The desk research and the interviews in the immersion phase will be the basis for the future vision. This phase yields a lot of insights from interviews and desk research. These insights can be clustered so that patterns emerge. Pattern creation is done with other people to avoid bias. It preferably happens with three people in total (H. Caspersen, personal communication, 22-4-2019). The clustering and pattern creation methodology changed throughout the project. How this changed exactly can be found in appendix D. The final clustering relied on a colour coding system. This made for an easy overview of the different types of insights. There was a distinction between an explicitly stated value wish (pink), an opinion on the future (blue) and a proven trend (yellow).

From the created patterns, future value wishes and their drivers can be identified.

Not all of these are considered for the creation of the vision. Four or five are chosen on basis of the impact on the users, the timing of this impact and the strategic fit with Barco. How this is done will be described in the results part of this chapter.

In summary: The patterns are the drivers of several future value wishes. A handful of them are chosen to determine the future vision.

“The vision expresses specific, achievable dimensions to making the difference” (Simonse, 2017). The point where the vision is both challenging and safe is called the strategic reference point, the point where every innovation professional in the organisation can relate to in some extent. The clearer the strategic reference point of the vision is, the more easily everyone can see how to build a path towards it (Simonse, 2017). The challenge is to formulate a future vision that clearly points to new values and one that is shared by others.

Four characteristics that a successful vision should have:

Clarity - The vision is clear, everyone understands the experience immediately.

Value - The vision captures the benefits of value wishes.

Magnetism - The vision energizes and attracts others to direct their action towards it.

Artifact – The vision is materialized in 2D or 3D for more tangibility.

The next chapter will elaborate on the results of the value mapping phase, including the trend patterns, the selection of these patterns and the future vision.

Results

Thorough desk research has been done and a total of ten interviews were conducted to uncover future value wishes. Ultimately these value wishes and their value drivers will lead to the desired future of Barco. Figure 13 shows an overview of all of the interviews that are conducted and where the interviewees are situated. The process of the desk research and interviewing can be found in Appendix D.

From the start of the trend patterns method, the amount of collected insights is huge. Displaying these all in this chapter is unpractical, therefore the complete overview of the used insights in the trend patterns can be found in Appendix E. The following part of the report is focused solely on the results of the value mapping phase.

All of the insights from the desk research and the interviews are clustered into a total of ten patterns. First, these patterns are briefly explained. Per trend pattern, some examples are given in the form of quotes from the interviews for illustration. Some of these quotes are in Dutch due to the language during the interviews. Note that these trend patterns are backed up by desk research as well. This desk research can be found in Appendix E as well. Second, the selection of the patterns is explained. This includes: the impact on different user groups, timing of this impact, strategic fit with Barco. Third, a total of five patterns is chosen to make up the future vision. Finally, the future vision is stated, visualized and explained.

Figure 13 - Overview of all the interviews with radiologists and their locations

List of patterns

This list contains a total of ten patterns with explanation and quotes from interviews. Not all of the insights are incorporated into this selection as some of the created patterns were too small to be included in this list.

Quantification of care

With the rise of new technologies that assist healthcare professionals, the amount of quantified data increases in parallel. The confidence in healthcare is changing from a subjective verdict from human professionals to a quantified and objective verdict by computers. This includes AI, Radiomics and IT trends.

Quotes:

"...informatie die we daarvoor gebruiken moeten we zo goed mogelijk quantificeren. Actionable maken. Anders is het natte vinger werk, gebaseerd op een subjectief iets."

"Ik denk dat een belangrijk deel van AI workflow optimalisatie wordt. Met contrasten weergeving, spoedpatiënten tussendoor, inplannen van patiënten."

"Dat denk ik wel: dat we veel meer informatie aangeboden krijgen, daarom zeg ik data analisten. Het is een verschuiving van morfologie naar functioneel en kwantitatieve data. Dus niet alleen de plaatjes beschrijven, dat is passe."

Healthcare becoming remote

A large part of the care for patients can be done remotely, away from the hospital. This includes teleradiology, radiologists working from home. Additionally, prevention and first line care are preferred over hospital visits.

Quotes:

"En het feit dat de huisarts bijvoorbeeld foto's kan laten zien met: hier ziet de radioloog de afwijking en dan kunnen we bij wijze van facetime nog extra uitleg geven."

"Want meer mensen willen van huis gaan werken en niet meer op het ziekenhuis zijn. En er is een trend dat mensen meer en meer op de beelden willen focussen. En niet zoveel meer op de ziekenhuizen te zijn. Er is een trend waar de radioloog eigenlijk verder weg van de patiënt gaat dan nu."

"...we need to have screens that fit this role. We need to have screens that cope with the fact that we are not in that very closed artificial environment and they need to cope with home environments."

Empathic radiologists

While technology and data play an ever-increasing role in healthcare, there are some tasks that cannot be automated. These tasks involve empathy and social and physical contact with patients or other specialists. This human side of care is important to patients and care-professionals.

Quotes:

"So we can concentrate more on the aspects that require human interaction: the empathy and complex interpretation side of things."

"gestructureerde data, waar zo'n computer heel veel mee kan. En dat geldt voor een aantal andere medische dingen niet zoals patiëntencontact, fysieke dingen zoals chirurgie, lichamelijk onderzoek."

"...de waardering van de werkgever om beelden te bekijken zal minder en minder worden in tien tot twintig jaar. En andere dingen, wat minder gebruikelijk is zoals patiëntencontact, MDO's sturen en informatie verzamelen."

Self-direction of health by patients

Patients make their own decisions regarding their health. As opposed to the past where doctors had all of the authority and credibility, the patients are now able to form their own (expert) opinion. They can ask for specific doctors and they can request a second opinion online. Additionally, the patients need answers to their specific questions about the diagnosis or treatment.

Quotes:

"Dus ik denk dat de patient eerder zal vragen van wat vind de radioloog ervan, ik denk dat dat makkelijker wordt. Ik denk dat we beter gaan communiceren en dat moet eigenlijk wel."

"...er bedrijven ontstaan en platforms ontstaan voor second opinions. Dat de patient denkt van kom maar hier met die scan, ik vertrouw het niet. En je betaalt 10 euro om het online te laten beoordelen en dan kom je terug naar de arts en het algoritme zegt dit. En wat dan?"

"In de US wordt soms de patient bij de MDO gehaald, die wordt dan ingebeld en die kijken mee over wat er besproken wordt."

Parallelization of imaging in healthcare

The usage of DI in care is increasing. This happens not only in depth (specialization), but also in breadth (parallelization). DI is not only used after referral, instead it is used in prevention, early detection and treatment among others (e.g. Radiography, Interventional radiology, surgery, first aid). DI is used as guidance and becomes integrated into various care processes, other than diagnosis.

Quotes:

"But the other aspect is that even treatment or diagnosis is now more closely aligned when things are put more into context and having a close dialogue. So treatment and diagnosis are overlapping nowadays."

"Vroeger zaten we helemaal niet op de eerste hulp. Als er radiologen bij de eerste hulp bij zijn dan worden patiënten eerder het goede pad in geleid en dit zorgt op zijn beurt weer voor minder heropnames."

"...ik denk dat beelden meer en meer belangrijk gaan zijn voor andere specialisten in hun werk. Niet alleen voor diagnoses, maar ook voor ondersteuning in andere dingen die ze doen."

Tech-Savvy radiologists

Because of a rapid increase in imaging techniques, visualization support and algorithms, the radiologist changes into an imaging shepherd managing a flock of available techniques. Being aware of these new possibilities and having the knowledge to apply them becomes a key role in their job. The actual work that radiologists carry out is becoming more and more connected to technology.

Quotes:

"Zoals de ideale radiologie afdeling van de toekomst waar elke afdeling een data scientist heeft."

" Ik denk dat we meer data analist moeten worden. We gaan meer de data die we aangeleverd krijgen moeten gebruiken. We gaan onze manier van verslagleggen totaal moeten veranderen."

"Het percentage AI zal toe gaan nemen. Mijn controlerende functie zal steeds meer toe gaan nemen. Wat komt er uit de AI, eens of niet eens."

Centralized patient data in the cloud

Patient data is getting more accessible as databases get integrated through the use of EMRs. This centralization ultimately leads to a solution referred to as a VNA (Vendor Neutral Archive). This database is then accessible to patients and care-professionals. The more data this database has, the better and faster the care and the healthier the patient. Computing of this data can be done on the same premise as well.

Quotes:

"What you need is some kind of globalized archive where you can extract data from, doesn't matter where it is because you can access it anywhere, and the means to access the imaging and manipulate the imaging in a diagnostic fashion."

"Ik denk dat er wel een moment gaat komen dat er veel bredere data beschikbaar is van die patient. Misschien zelfs de soort virtuele kopie, de virtual twin van die patient."

" het meest ideale is om ervoor te zorgen dat er een beveiligd systeem komt wat beschikbaar is in t hele land. En dan heb ik het over een soort centraal archief. Gereguleerd door de overheid zou kunnen, maar blockchain zou ook een rol kunnen spelen. Dat de patient de touwtjes in handen heeft."

Integration of hospitals and systems

For hospital systems (PACs, RIS, EMR) to be as efficient as possible, they have to work flawlessly together. Providers are increasingly delivering complete systems for a better workflow. Additionally, hospitals are clustering together to become subspecialized. One data format is needed to support the complete integration.

Quotes:

"Efficientie van de systemen kan beter, beter geintegreerd met elkaar en de wachttijden omlaag."

"Ik denk dat wat belangrijk is is dat je niet de producten samen koppelt maar dat je de metadata en principes samen koppelt. Dat formaat van communicatie is dus besloten in plaats van te zeggen dat iedereen dit of dat merk moet hebben."

"I think I would love to see better harmony between suppliers and users so we can co-develop things."

Complex diseases cause collaboration

An increase in (sub)specialization and the increasing amount of complex diseases (various causes that are not yet fully mapped) causes care specialists to collaborate more. This expresses itself in an increase in number of multidisciplinary meetings and communication or referrals.

Quotes:

“Als ik naar longbesprekingen kijk, hoe vaak we daar dingen de goede kant op kunnen bespreken, hoe groot de toegevoegde waarde daar is verbaas ik me elke week over. Daar zou ik het liefst al mijn tijd in stoppen.”

“Wat een hele belangrijke ontwikkeling is, in de communicatie tussen medische specialisten.”

“We went from people sitting in a dark room to being involved in tumour boards and MDOs. So there is more involvement in patient management than it was before. So the solutions we use need to reflect these changes as well.”

Personalized care

A lot of information and data is available per patient. This creates the possibility to tailor the care to be made for the patients as individuals as is described by personalized medicine. This involves regarding the history, the family and the DNA of the patient.

Quotes:

“Ik denk dat het veel belangrijker is dat we beelden en de vraag die we nu hebben als een deel van het leven van een patiënt met een geschiedenis en een actuele vraag zien. En in die context eigenlijk te beantwoorden.”

“Het zal meer in die kant gaan: Dat we de data analyse voor een groot gedeelte overlaten aan helpers en software en dat wij dan uiteindelijk het globale plaatje proberen te zien, meer vanuit een holistisch perspectief.”

“Dus je gaat veel meer die personalized treatment krijgen op basis van de diagnostiek in je behandelperiode, daar kun je veel in verbeteren. Dan hoef je veel te dure medicatie niet te geven aan mensen waarbij je weet dat het toch niet goed aangrijpt en dan kun je veel gerichter behandelen.”

Selection of the patterns

What follows is the selection of the patterns according to the three selection criteria: user impact, timing and strategic fit.

The amount of impact a pattern will make is dependent on the user that is being impacted. The three biggest user categories are radiologists, hospitals and the patients. Radiologists are the main users of the products. Hospitals are organizations and no users in the traditional definition, however they have demands and deciding power over the products/services. This is the reason that they are included in the list. Patients are not really users at this moment as they never use Barco's products. However, the patients determine the ultimate value of the innovations because their health depends on the accuracy of the products/services that Barco provides. Additionally, patients cannot be excluded as 'future' users in this stage.

The user impact is rated on a scale of 0 to 5 by myself. The basis for the rating by me is rooted in the experience with the field through the immersion phase of trend patterns. Take note that these are estimations of user impact as there is no real manner in which it can be tested. Neither are the ratings of user impact comparable between user groups as they are rooted in different values. The impact of the trend patterns on the different user groups is visualized in figure 14. This overview will be used in choosing the patterns that will make up the future vision. The most important determinant here is the user impact on the radiologist as they are the actual users of the products.

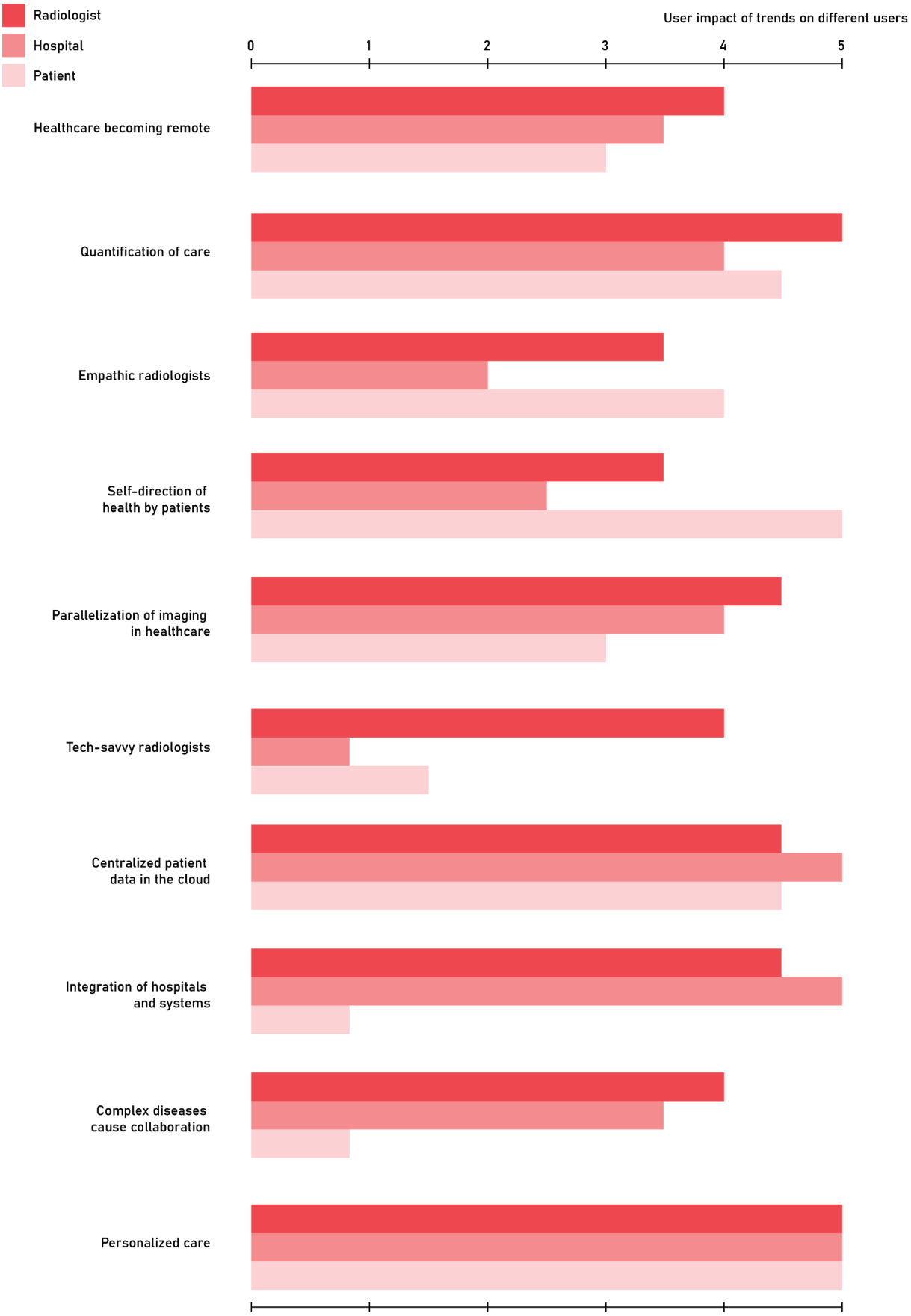


Figure 14 – User impact of trend patterns on user groups

All of the patterns can be seen in figure 15 with the estimated timing of their impact. The patterns already have their effect at this very moment, but this effect is relatively small when compared to what the effect will eventually be. The moment when the pattern will make the biggest impact, the moment of change, is characterized by the circle with the icon. After this moment, the pattern continues to develop. The timing of the change is based on insights from the desk research, interviews with radiologists and interviews with professionals within Barco. Ideally, the impact of the patterns is spread over multiple years. In this way, innovations can be successive and built upon each other instead of Barco relying on a few or even a single moment to innovate.

Finally, the patterns are rated on the strategic fit with Barco. This is done with two prominent people in the Barco healthcare segment. They were left free in determining the fit. However, they were reminded on the focus on end-to-end solutions and the 'Value stack' (see 'Context analysis') to make sure that the selection was based on strategic fit and not on personal preference. Again, this was a rating on a scale of 1 to 5. An overview of the sum of scores that were given can be seen in the right side of figure 15. The maximum achievable score here is 10. A photo is taken of a Barco employee rating the patterns on strategic fit, this can be seen in figure 16.

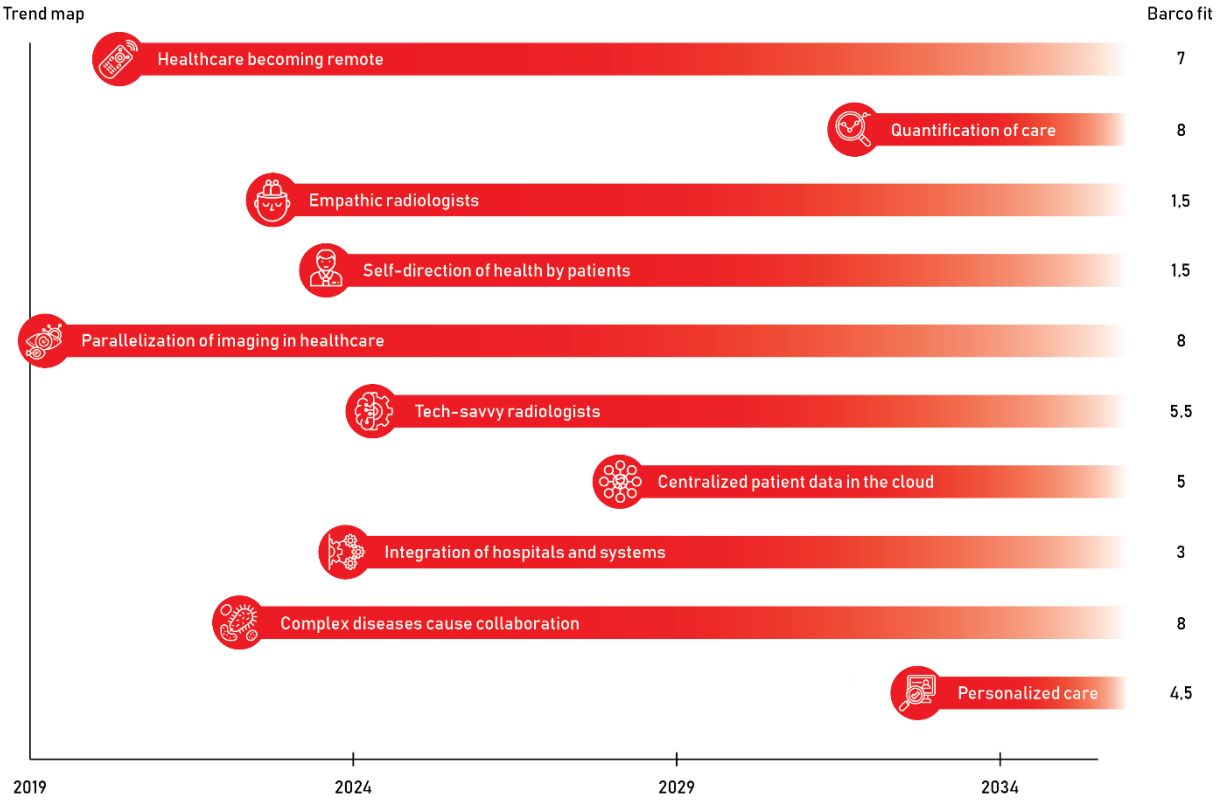


Figure 15 – Time of impact and strategic fit of trend patterns

Figure 16 – Barco employee rating the patterns on strategic fit.

A complete overview of the trend patterns and their scores for user impact and fit with Barco is shown in the table below. The user impact score of the radiologist is regarded as they are the focus of this research. The timing of the trend patterns cannot be expressed in a number and is therefore left out from this overview. In this table, the trend patterns with a combined score of 10 or higher are coloured green.

Trend pattern	User impact	Barco fit	Total score
Healthcare becoming remote	4	7	11
Quantification of care	5	8	13
Empathic radiologists	3,5	1,5	5
Self-direction of health by patients	3,5	1,5	5
Parallelization of imaging in healthcare	4,5	8	12,5
Tech-savvy radiologists	4	5,5	9,5
Centralized patiënt data in the cloud	4,5	5	9,5
Integration of hospitals and systems	4,5	3	7,5
Complex diseases cause collaboration	4	8	12
Personalized care	5	4,5	9,5

Based on the three criteria, a selection of five trend patterns was made:

- Healthcare becoming remote
- Quantification of care
- Parallelization of imaging in healthcare
- Complex diseases cause collaboration
- Tech-savvy radiologists

These five trend patterns have high user impact. Additionally, the timing of the impact is nicely spread across several years. Also, the strategic fit with Barco is the highest of all the patterns. The trend pattern 'Tech-savvy radiologists' is chosen because of its highest fit with Barco when compared to the two other patterns that had a similar combined score.

These trend patterns are projected fifteen years into the future. Their expected state is described in a fictional manner. This overview can be seen in figure 17.

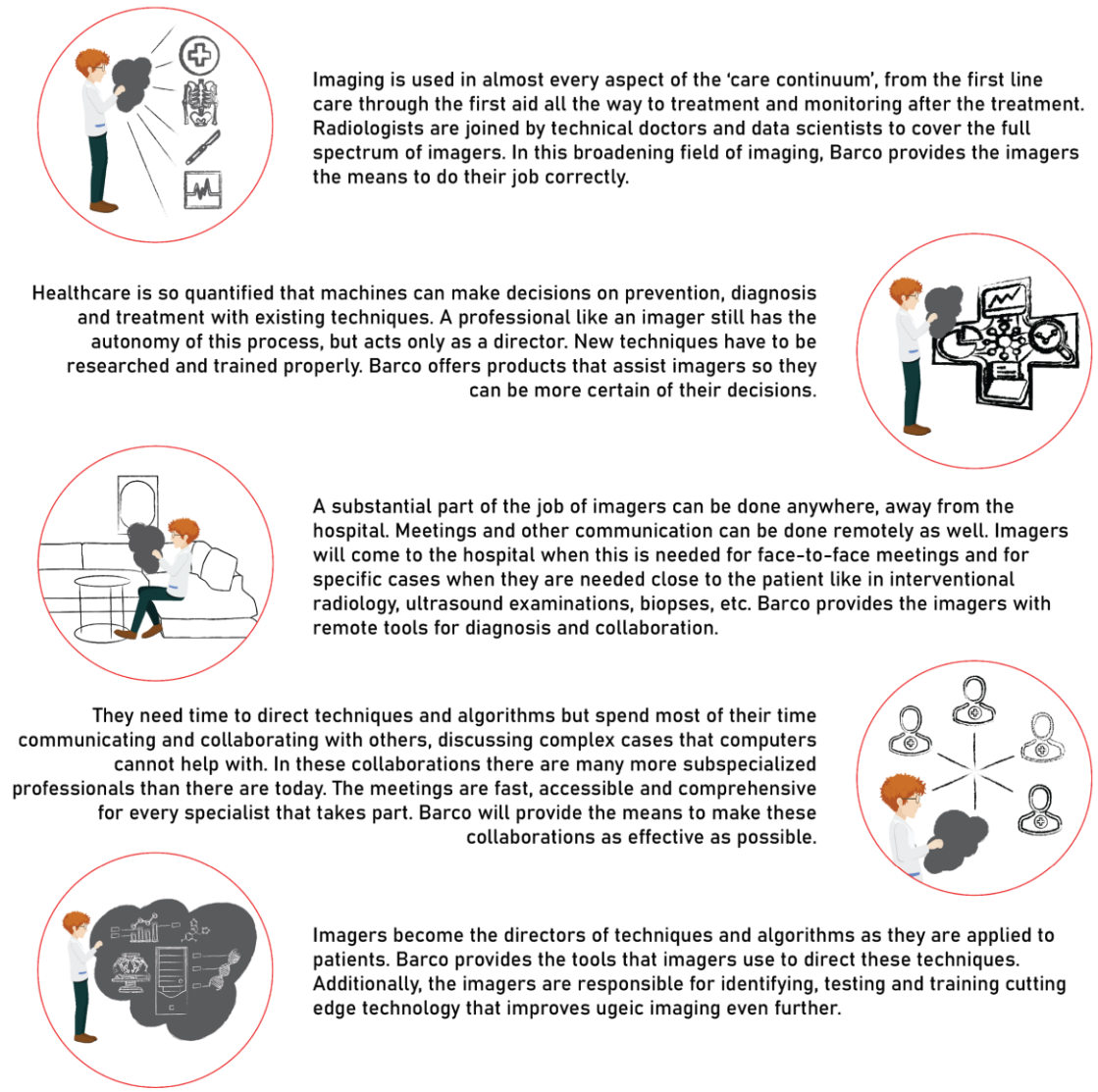


Figure 17 – The future of trend patterns

This fictional overview explains the future of the trends and hints to the future vision. From this overview, five future value wishes can be derived. These value wishes are similar to the trend patterns but they explain the view from the 'imager' better.

These five patterns are rooted in five value wishes for the future work of radiologists:

- Remoteness: The ability to work remotely or work outside of the hospital
- Certainty: The feeling of competence of diagnosis through innovative tools
- Accessibility: Being accessible to other specialists and being able to access more data and systems
- Collaboration: Working together with other specialists and colleagues
- Tech-savvy: Being the director of techniques and algorithms

Future vision

Combining the value wishes into one whole creates the future vision. This is the desired future for Barco where they can add the most value for the imagers. The future vision comes with a vision statement: seamless & certain care & collaboration. This statement aims to combine the different value wishes into one sentence. These elements are visualized into an artifact. The artifact shows an imager with Barco as a co-pilot. Around the two are their direct responsibilities in the future. The artifact can be seen below in

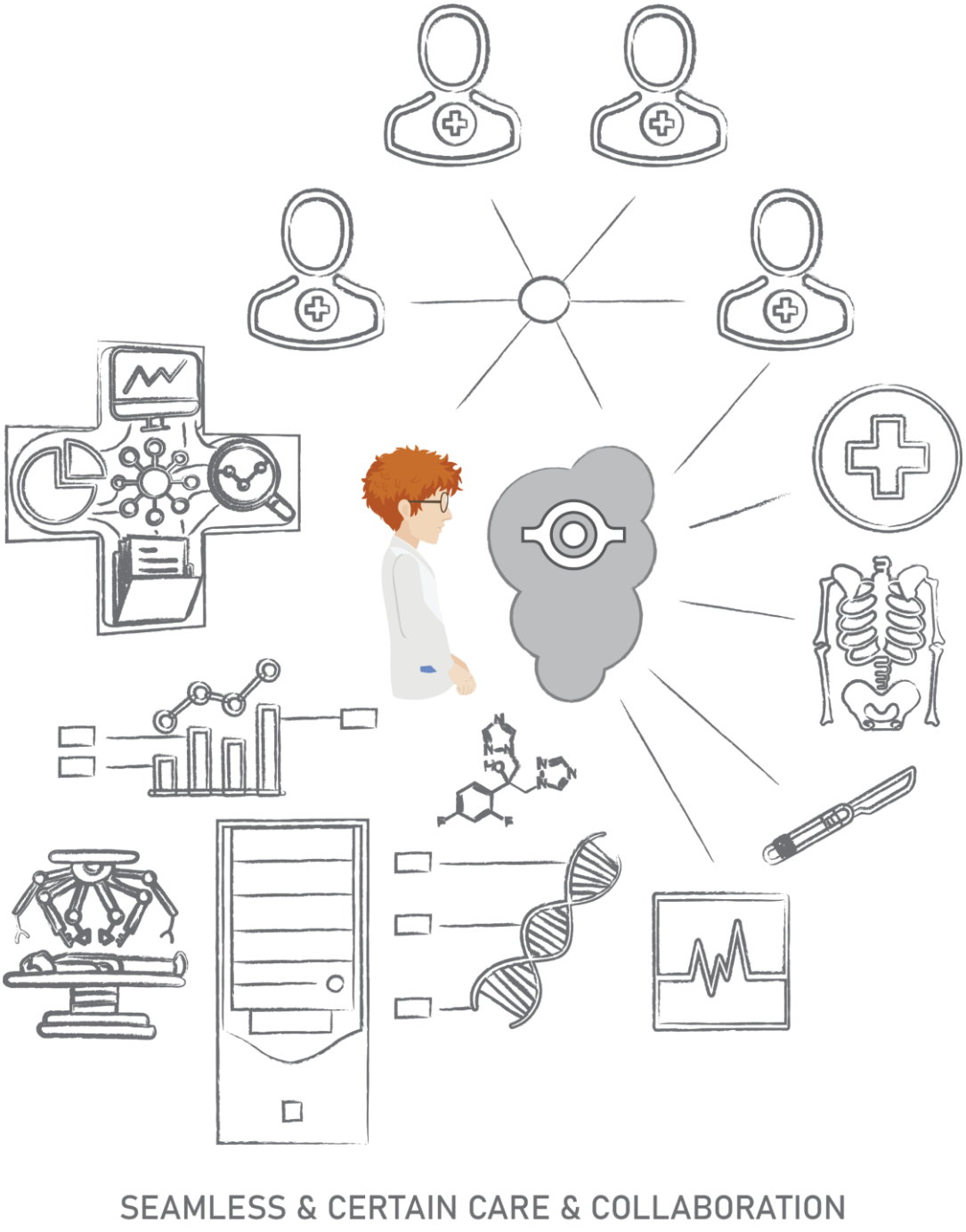


figure 18.

Figure 18 - Future vision artifact

An important thing to note is that this vision is discussed with many people in Barco in order to create support and understanding of the vision. This is called the 'championing' of the vision and it continues until the end of the project.

The future vision will act as the goal and the destination of the roadmap. In the following chapter the preparation for the journey will be described, this is done according to the idea mapping method from the roadmapping book.

Preparing for the journey

Now the destination of the journey is chosen, the time has come to prepare for the journey. This happens in three ways: defining tools for on the road, time planning and determining vehicles. Preparing for the journey relates directly to the idea mapping phase from the roadmapping book.

With a formulated desired future for Diagnostic Imaging, the road to this future can be mapped. This happens in the Idea mapping phase. First, all of the technologies that can help in facilitating the future vision will be researched. Relevant technologies are mapped and a few are selected that will play a role in the innovations on the roadmap. This part is called technology scouting. Second, the timing of the roadmap needs to be determined in the time pacing part. Here, the innovation cycles of Barco, their competitors and hospitals are considered and they form the basis for the time frame of the roadmap.

What follows is the actual mapping of ideas on the timeline based on the discovered technologies. This happens in a mapping session with stakeholders in Barco. The mapping session was done with the affinity mapping method. More about the method and the results of the session in the 'Mapping session' part.

Defining tools for on the road

When embarking on the journey, the appropriate tools have to be defined to take along on the journey. Defining tools for on the road relates directly with technology scouting from the roadmapping book.

Two main activities are carried out to discover upcoming technologies for the technology scouting: Desk-research and interviews with experts within Barco. The desk-research was shown in the meetings with the experts to get their opinion on various technologies. The search could not be limited to 'medical displays' as there is no guarantee that a display will still be the format for viewing images in the future.

Technology scouting method

The Content Value Cycle (CVC) is used as a basis for discussion and as a way to separate the technologies into different categories. The different quadrants of the cycle can be seen as strategic modules and it can be seen as a guiding radar that assists in searching for technologies.

This cycle represents the four categories of value creation in handling content, in this case medical images. The cycle starts with 'content creation', this is where the images are acquired by devices like MRI or CT scanners. The content then proceeds to 'process and control'. This is a rather broad category as it includes connectivity, storage, processing and potentially AI applications. Everything that happens in between the acquisition and visualisation is part of this category. Then, 'visualizing' regards everything that makes the content visible to be interpreted by humans. This currently includes traditional screens but it could potentially include projectors, holograms, Head Mounted Displays or 3D-displays. Then, the final category 'interacting' includes everything that regards the interaction from the user with the content. Currently, this includes a microphone in the screens for reporting, 'Spotview' or other software that improves the workflow and viewing quality respectively. The interaction can then be used as an input for the cycle again. A visualisation of the cycle can be seen in figure 19.

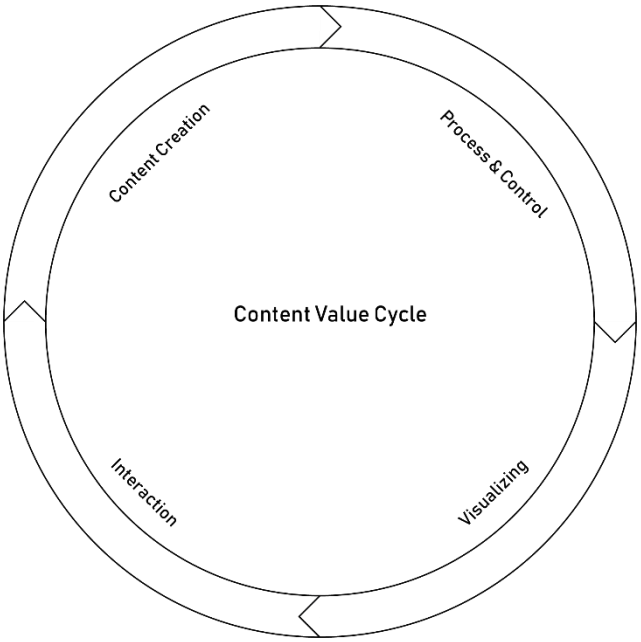


Figure 19 – Content value cycle

A total of seven experts with different experience were interviewed, some of them multiple times. An overview of the interviewees and their function is given below:

Business Unit	Function	Number of meetings
General Services	VP Technology	3
	Sr. Expert Display Technologies	1
Healthcare	Expert Engineer	5
	System architect	5
	VP Modality Imaging	1
	Director Product Management	1
	Senior Product Manager Diagnostic Imaging	1
	Vice President Technology and Innovation	1
	Program Manager Modality Products	1

The dates of the interviews can be found at the end of Appendix F.

Their input was carefully documented and brought to the meetings that followed. In this way, the experts could react to the input of others and this made for sessions that added to each other. The first sessions were explorative and were meant to discover technologies no matter the relevance for Barco. A photo of the outcome of one of those sessions can be seen in figure 20. In the ending sessions the relevance to Barco and possible impact on the user was considered. In these sessions the timing of the technologies was discussed as well, this will be further explained in the part 'Time pacing'. A photo of the process can be seen in figure 21. In this photo, the pink notes represent technologies on the timeline.

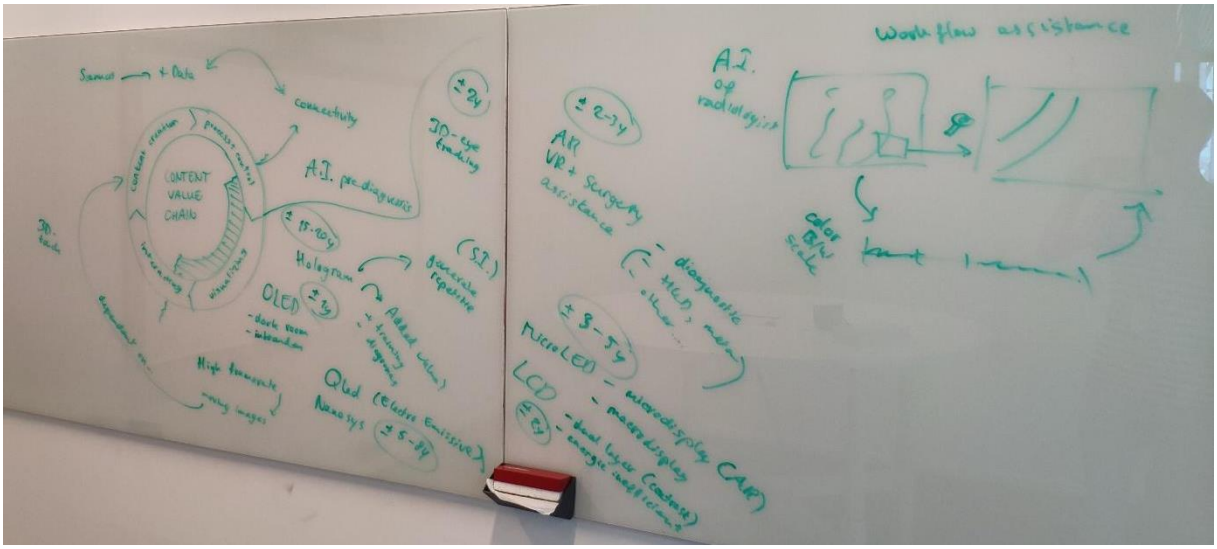


Figure 20 – Photo of the results from one of the earlier technology scouting sessions.

Figure 21 – Engineer explaining a technology in one of the technology scouting sessions

Technology mapping results

The input from the interviews was gathered and a large list was made with all of the mentioned technologies. This list can be found in Appendix F. Not all of the technologies in this list are of relevance for the user or for Barco. Together with Barco employees, a selection of the most relevant technologies was made. This can be seen in an overview in figure 22. The further the technologies are to the outside, the longer it takes for them to be fully developed. Some of the technologies are not technologies but rather specific applications of a technology. These are represented in the blocks that are coloured grey.

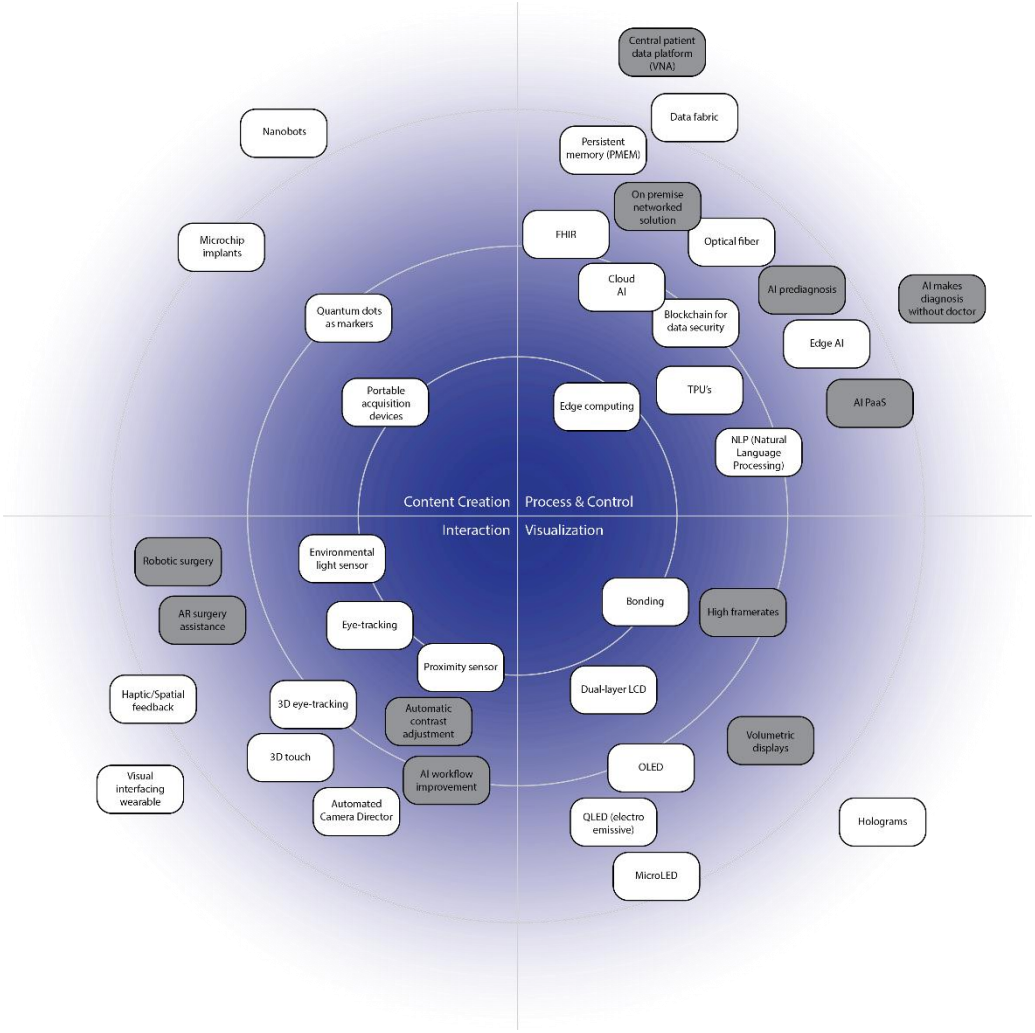


Figure 22 – Technology scouting results

Another selection was made from the technologies in the overview. A total of three engineers and two product managers were asked to make a top five of the technologies based on the following variables.

- Urgency
- Strategic fit
- User impact
- Feasibility

User impact and feasibility are the most important variables here because if any of these is not reached, the innovation will fail automatically.

Chosen technologies

The technologies that were selected based on these criteria are listed on the following pages with a short explanation of the technology and possible use-cases:

1. Edge A.I.

"Edge AI means that AI algorithms are processed locally on a hardware device. The algorithms are using data (sensor data or signals) that are created on the device" ("What is Edge AI?", 2018). As opposed to cloud A.I. where data is processed in servers that are far away from the devices themselves. Edge A.I. has the benefit that processing can be done in the device itself so it needs less data transfer, the user has the ability to work offline and it is more secure. For applications that provide real-time interaction with humans, Edge A.I. is needed because of the fast response times in comparison to Cloud A.I. (Sr. Product Manager, personal communication, 27-8-2019). Cloud A.I. is essentially the opposite of Edge A.I. It refers to artificial intelligence that is based in servers or data centres. It has the benefits of data access, smarter decision making and cost savings by centralizing a large amount of the processing. Cloud A.I. is best used for learning purposes because of its accessibility or for large datasets that need a lot of processing. Edge A.I. could be used in the future vision as the processing unit in monitors. It can be used for processing power in remote applications as they can work offline, not depending on a slow internet connection. The difference between Edge A.I. and Cloud A.I. is illustrated in figure 23. Visualization of the data or a changing User Interface will have a similar latency difference.

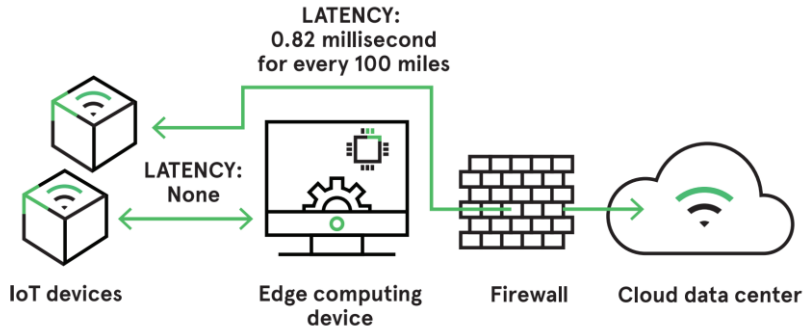


Figure 23 – Difference between Edge and Cloud ("A.I. at the edge", 2018)

2. A.I. PaaS

This refers to the use of a platform for A.I. that is provided as a service. It is a middle ground between a platform-as-a-service and A.I.-as-a-service and it will be able to develop a strategy on the fly for specific problems (Dooley, 2017). It is not a technology in the traditional sense but rather a business model that has a new value proposition. The platform itself is not necessarily based on A.I. but this can be added later. This platform gives an overview of different algorithms that can be used by the radiologist. Barco can provide an A.I. platform where there are different algorithms that can be bought or hired as a sort of 'medical app-store'. The platform may even be used as a connection to Care Consultation and even assist in the collaboration between specialists (remotely or locally). Ideally, Barco makes use of Edge A.I. in displays for assistance that is needed immediately and Cloud A.I. for training purposes and larger applications like the A.I. platform, where accessibility and scalability are more important.

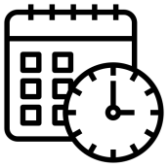
3. Micro LED

Micro LED is a new technology for flat screens that have a significant amount of potential performance advantages over LCD displays. This includes "lower latency, higher contrast ratio, and greater colour saturation, plus intrinsic self-illumination and better efficiency" (Cheng, 2016). Micro LED is a useful technology for smaller devices due to the low energy consumption. It is also promising for devices that need high contrasts and high luminance. For Barco, Micro LED can provide a more accurate and faster diagnosis through higher contrasts. Because of the high luminance, Micro LED can offer a viewing experience that is up to standards, even in an environment with more light. Additionally, Micro LED may provide more remote energy-efficient solutions like smaller screens or even a head mounted display. MicroLED can be made as a transparent screen as is shown by Tianma (Mertens, 2019).

4. Local workflow assistance

This is a very broad definition and rather an application of technology that includes every possibility to help the imager in their work. However, there are multiple options of technology that can be a part of this application. As it is now, there are some intuitive tools that the radiologist can use like SpotView and DimView. More recently, Screenpoint Medical works together with Barco to flag areas of interest for the radiologist in Mammography. Eye-tracking could be used for analysing the workflow of the radiologist and improving viewing or reducing eye-fatigue based on this data. These workflow applications that run locally ideally have Edge A.I. that is used for the processing because of the direct interaction with humans (Sr. Product Manager, personal communication, 27-8-2019). Regarding hardware: a microphone, camera, environmental light sensors and other modules can be added to make the viewing experience up to standards, more accurate and faster. Even if the imager is not in the hospital.

These technologies promise high relevance in the future. However, these are not exclusively the technologies that will be used in mapping the ideas on the timeline. How the ideas mapping sessions are organized will be explained in the 'mapping session' part.



Time planning

With the tools for on the road defined, the vehicles can be defined as well. However, a time planning is made before the vehicles are discussed. The time planning relates directly to the time pacing phase in the roadmapping book.

The goal of time pacing of the strategy is to determine the timing of the innovations that will map the road to the future vision. This road is divided into three horizons that depict three parallel scenarios that all have their specific life cycle of strategic business innovation:

- Horizon 1 focuses on existing market with existing technology: Design value enhancements
- Horizon 2 connects horizon 1 and 3 by either a new market or a new technology: Value User-centred value creation
- Horizon 3 focuses on new markets with new technologies: Value proposition creation

These three horizons of strategic life cycle need smooth transitions as they overlap partly and go through a transition period of the previous life cycle losing fit with the market. To enable the smooth transitions between the horizons, design clocks are used. Design clocks can be fast or slow and describe the speed in which a product or service gets innovated. Horizon one typically has a fast design clock, a 'new version' innovation. Horizon three has a slow design clock, the innovation takes a while because of the new business development. Horizon two sits in between with a moderate clock speed.

How fast specifically these clocks are is determined by innovation cycles of Barco and of their competition as well.

Innovation cycles

An interview was conducted with the Product Manager of Diagnostic Imaging Displays. She was able to tell me that their pace of innovating is dependent on new technology, End-of-life of components, competition and otherwise on warranty conditions. These warranty conditions are typically quite long: five years for diagnostic displays and three years for clinical review displays. She added that the clients of Barco do not wish shorter cycle times unless it offers them a clear clinical benefit (Product Manager Diagnostic Imaging Displays, personal communication, 13-8-2019). Potential innovation projects are discussed in the SMP meetings as well, where the business unit looks into the future for three to five years.

Competitive timing

To be able to anticipate on the competition, the innovation timing of the competitors is analysed. This is done by looking at the organizations portfolio and documenting when specific product launches are made and drawing these on a timeline. After this overview is made, a certain rhythm can be described of when there are product 'updates', whole new series or more innovative developments. Because of the prevalence of Eizo as their undisputed competitor, this is the only organization that is analyzed for this project. Eizo's product portfolio related to diagnostic displays and review displays, the RadiForce collection, is traced back ten years until 2009. An overview of the timeline and the product launches can be seen in figure 24.

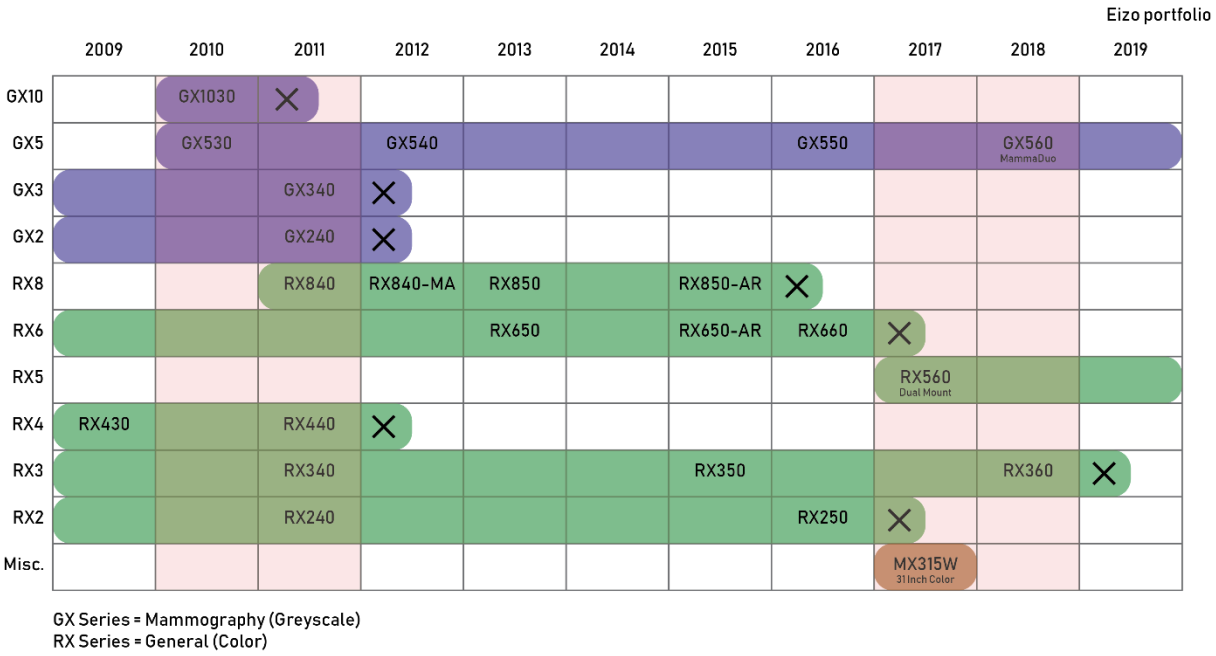


Figure 24 – Portfolio analysis of the diagnostic imaging products of Eizo

This overview gives a few insights into the innovation cycles of Barco's biggest competitor. The cycle time for the product updates of their successful top line is around two years (the GX5 series and the RX8 series). These are simple updates on software, aesthetics and display quality. These incremental innovations continue and once in a while a new series gets launched. This is something that they did in 2010 and 2011 with the GX1030 and the RX840. They launched two new series again in 2017 with the RX560 (this series has a specific stand that can be used to put two screens together. The screens are optimized for viewing together). This same mechanism was used in the launch of the new model GX560, better known as the MammoDuo. In 2017 Eizo also launched the largest screen and resolution of their MX lineup, the MX315W. The cycle time for new product series is around seven years approximately. It is hard to notice in this overview what innovation cycle Eizo has for more radical innovation.

According to this information, Barco should keep innovating every two years to be able to provide the same innovation cycle. Or in the client's case: warranty or end-of-life cycle. In this way, Barco can gain more market share when clients have the ability to choose between Barco and Eizo. Additionally, according to the series launch timing of Eizo, Barco should be prepared for new products of Eizo around 2024.

Technology timing

The future vision, its underlying future values and the scouted technologies all have their specific timings. The timing of the future vision and the values are already discussed in the value mapping phase: The future vision is based around 2034, fifteen years from now. The future values of the imagers have their timings based on the timings of the underlying future value drivers. The timing of the readiness and ability for Barco to do something with the technologies is discussed in the internal interviewees during the technology scouting sessions and mapped on a timeline. Some of the connections between technologies and user values are drawn already. A photo of the last version of the timeline is given in figure 25.

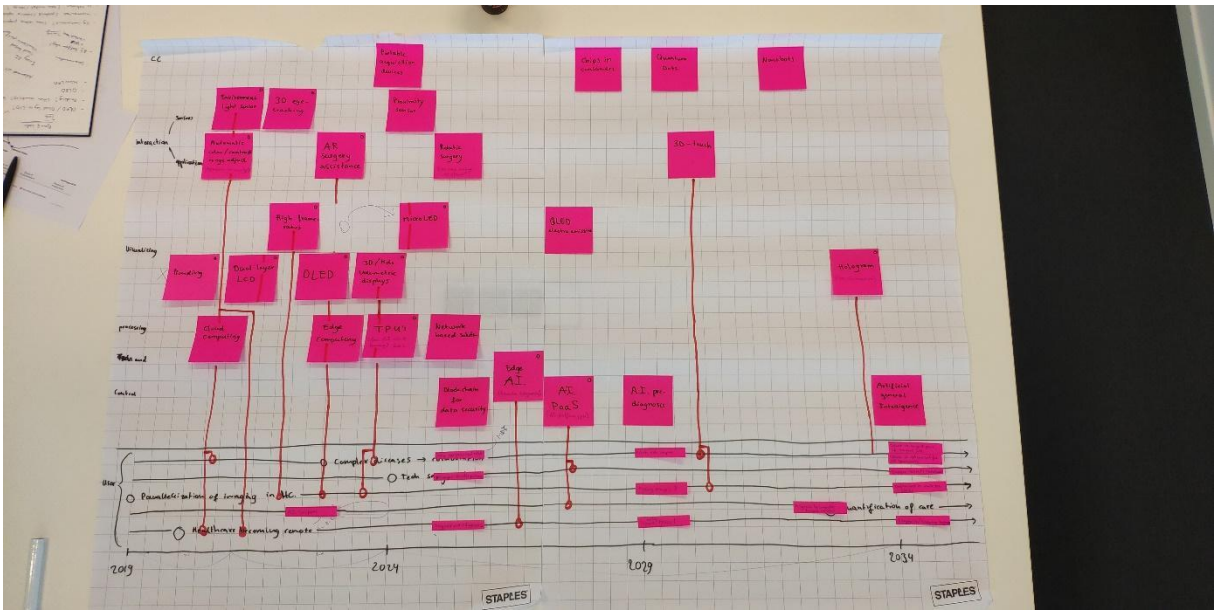


Figure 25 – Timeline of technologies and their relevance

With the insights of the innovation cycles, the competitive timing and the technology timing, the time frame of the three horizons was decided. An overview of the Horizons and their timings can be seen in figure 26.

The update time for medical displays is chosen as Horizon 1, until 2021. The next series launch of Eizo is expected to be in 2024, this is also five years from now (SMP). Thus, Horizon 2 will stretch from 2021 to 2024. Horizon 3 represents 2024 to 2029 because of the SMP timing and the warranty cycle of both Barco and Eizo of five years.

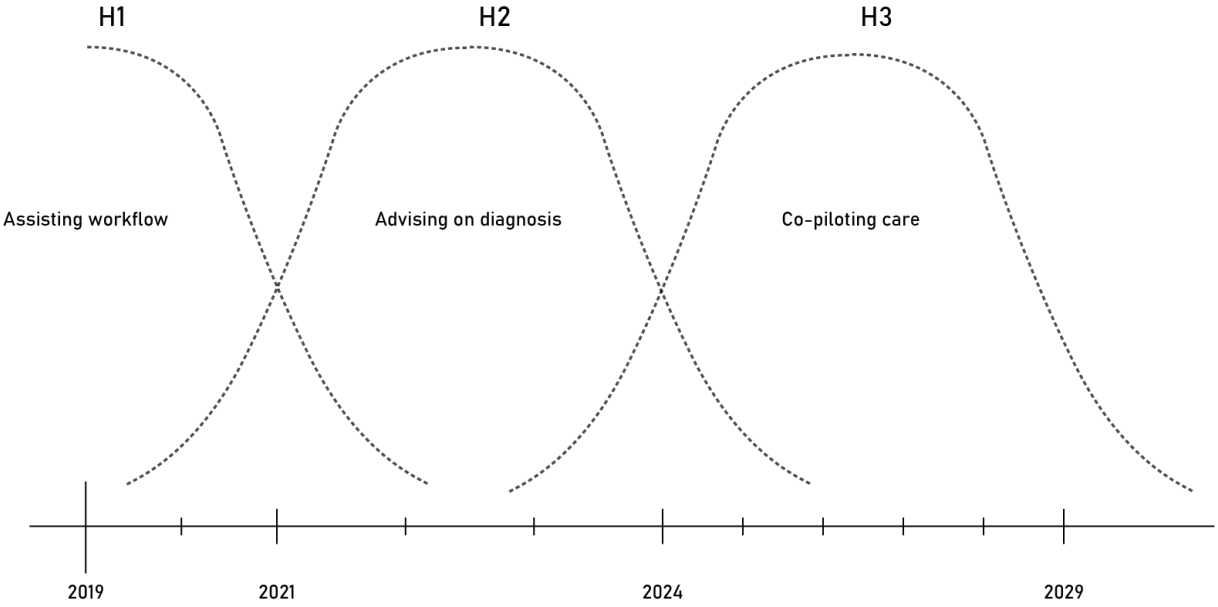


Figure 26 – Timing of the three horizons

Defining vehicles

The preparations for the journey are nearly finished. The destination is clear, there are tools for on the road and the time planning is made. Now it is time to determine the vehicles that will take Barco to the destination. Defining vehicles is directly related to the idea mapping sessions from the roadmapping book.

A total of two sessions were held to give body to the roadmap. The first session was mainly based on coming up with ideas based on the technology while the second session was also aimed at thinking of the relation between ideas and the relation between the other layers of values and technologies. The second session was also used to put the ideas into a time perspective. The method used for the idea mapping sessions is a version of affinity mapping. It is however simplified, due to time constraints.

Before the session

The participants received blue sticky notes and a marker. A draft roadmap with the value layer already added lay on display. Figure 27 shows a picture of the set-up of the second session. In the first session, an image of the results of the technology scouting phase lay on the table for inspiration. The participants were asked to read the value layer again and keep it in mind for the duration of the session. The participants were told that interaction between each other was desirable, but after they have thought for themselves for a minute or two per technology. The most important technologies would be discussed and ideas would be generated. After that, the ideas are clustered and are possibly divided into strategic modules. Finally, the connection between the ideas and/or strategic modules is explored. This was explained to the participants.

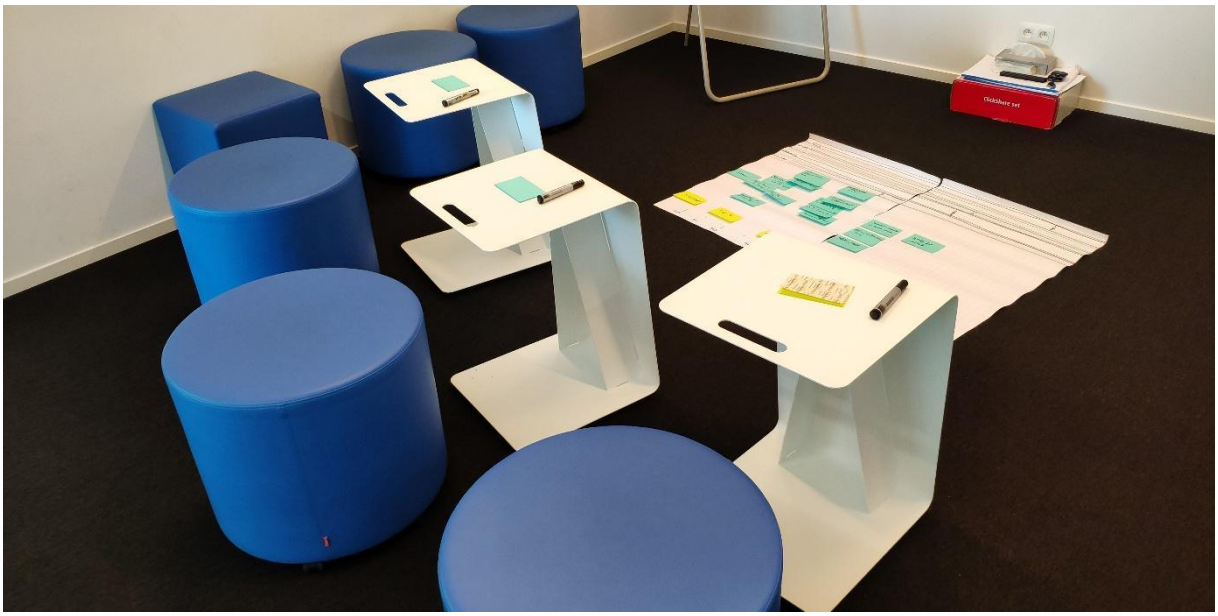


Figure 27 – Set-up of the second session

During the session

One by one, the technologies that were voted as most relevant were briefly explained by me to the participants. For every technology that I mentioned I asked them to write down the ideas that came up in their minds. The ideas could range from applications of the technology to fully developed internal ideas.

After the participants were done with thinking of ideas, they were asked to explain their ideas to each other. This yielded discussions about the relevance and the impact of the idea. Additionally, the discussion forced the participants to think of the feasibility of their ideas.

When the participants explained their ideas they were asked about the relevance for the user. Ideas that did not have any connection with the values were eliminated. This happened with the relevance for Barco as well: Ideas that did not have strategic fit or no relevance with in-house competence were left out of the process.

The technologies that were used as a starting point were:

- Edge AI
- AI PaaS
- Micro LED
- Eye-tracking
- NLP (Natural Language Processing)
- Automated Camera Director
- 3D Displays

Eye-tracking and Natural Language Processing are considered as technologies for local workflow assistance as mentioned in the part chosen technologies. Automated Camera Director and 3D displays are internal developments in Barco that might be used for ideas in the roadmap. The participants were asked to come up with other technologies as well if they seemed relevant. Figure 29 and 30 show pictures of the participants writing down their ideas and the participants discussing an idea in the first session respectively.

Figure 29 – Participants ideating in the first session

Figure 30 – Participants discussing an idea in the first session

Idea mapping results

A couple of ideas were not useable as they were more descriptions of benefits of the mentioned technology. These were discarded.

An obvious incremental innovation path is giving the screens more pixels, contrast or brightness. However, the limits of this path are almost reached as the human eye becomes the limiting factor in detecting details (Vice President Technology and Innovation, personal communication, 25-7-2019). Increasing resolution, contrast and brightness will therefore not be regarded in the idea mapping. See

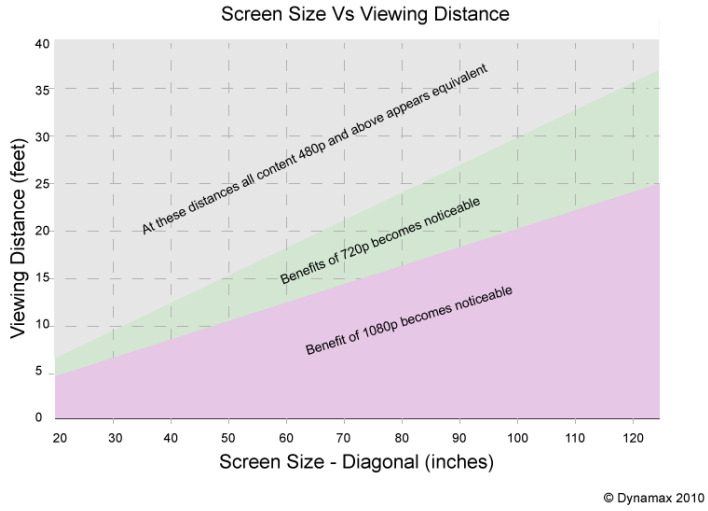


figure 31 with the explanation in grey for more information.

Figure 31 - Screen size vs. viewing distance (Dynamax, 2010)

The law that describes the smallest change in stimuli that can be noticed, a just noticeable difference (JND), is known as the Weber-Fechner law (Ekman, 1959). The law essentially describes that the perceived change in stimuli is proportional to the initial stimuli. How these relate to each other depends

on a set of variables. For noticing differences on a screen these variables are the resolution and the viewing distance (see figure 31). The graph shows that past a certain distance, a high resolution does not affect the ability to detect detail anymore. This law shows that it does not make sense to increase the resolution further when the limit of the human eye is reached.

After the first session it became apparent that the ideas all relate to three central innovation paths within Barco: Diagnostic Imaging core business, AI as a platform and Care Consultation

The core business here is represented by the screens and incremental changes to them. AI as a platform is something that is being innovated in DI at the moment but does not belong to their core business. Care Consultation is one of the incubators that Barco has and it revolves around the collaboration between care professionals.

These are key areas that correspond directly with the future role of the imager and their relevance with the value layer is clear to see. The second session started with the explanation of these areas of innovation to the participants. The participants were asked to think of these areas when coming up with timing, connections and strategic modules. The results from the second session can be seen in figure 32.

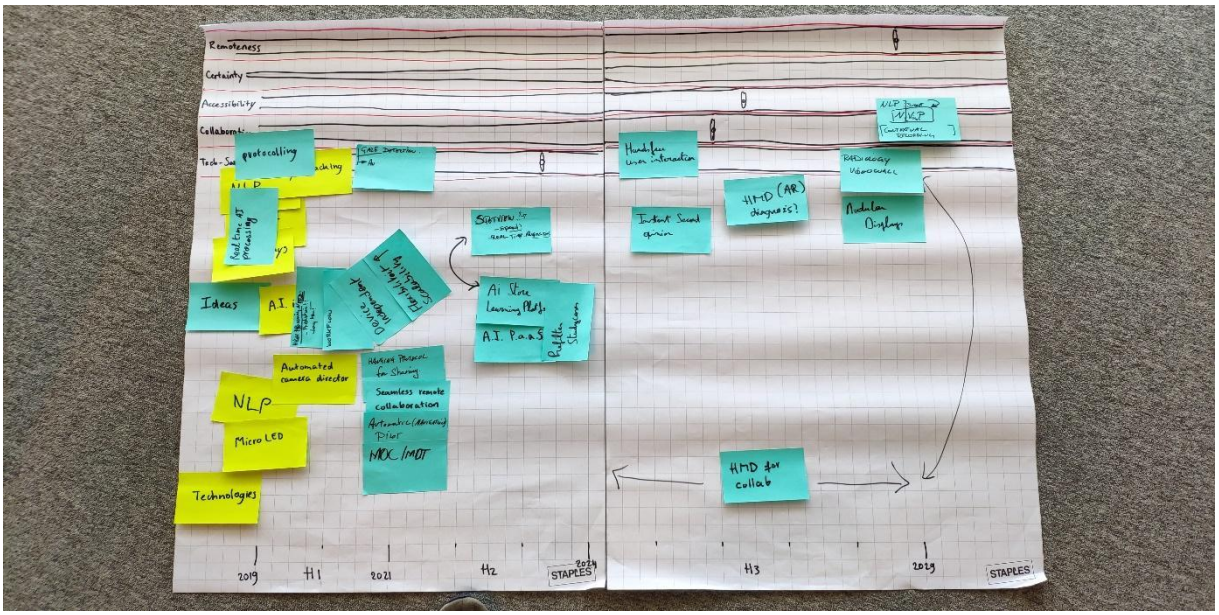


Figure 32 – Results from the second session

The two sessions yielded enough ideas. A couple of the ideas were left out because of the disconnect with the user, with Barco or with the other innovation areas.

For all of the remaining ideas, the needed technologies were explored and the timing of the innovations was mapped. This happened according to the technology scouting and the time pacing results. See figure 33 for an overview of the process.

Figure 33 – Process of idea fit with technology and time

Creating the roadmap

All of the choices in defining the destination and preparing for the journey will come together in the roadmap. This map describes the destination, the goal of the map, and the reasoning behind the goal. It describes the tools that will be used during the journey, the vehicles that are used and the time that these vehicles are used. This part of the chapter explores the creation of the roadmap, explains the final roadmap and suggests the implementation of the roadmap in Barco.

While placing the ideas and technologies into time, it became apparent how the three horizons would follow up on each other and how they will together lead to the future vision. As the radiologist changes into an imager, the role of Barco will change accordingly. The radiologist used to have full autonomy in the decision-making process. Nowadays, the radiologist is increasingly helped with making decisions on diagnoses. In time the radiologist will evolve into an imager and more and more of the decisions are made by machines. Barco will assist them, advise them, and ultimately co-pilot them with valued innovations.

This evolution of becoming more and more of a deciding factor creates the need for increasingly smart innovations. The amount of smartness that an innovation has consists of seven dimensions: ability to cooperate, adaptability, autonomy, human-like interaction, multifunctionality, personality, and reactivity (Rijsdijk, 2006). A few of these dimensions are of relevance for the healthcare field and they should be watched closely. Of these characteristics, the human-like interaction and multifunctionality have a large role in the innovations on the roadmap. While the decision-making role of innovations on the roadmap change, the interaction and multifunctionality change as well. This facilitates the strategy of Barco in expanding from visualizing to interaction and to control.

The roadmap describes the steps necessary to get to the desired future. It effectively combines the side of the user with the side of technology in the context of Barco and timing. The final roadmap can be seen in figure 35. The roadmap can also be found in a bigger format in Appendix G. The roadmap is explained through exploring its three horizons. This is done in the following part.

Three horizons

The three horizons in the roadmap build on each other and describe an increasingly seamless experience for the imagers while the role of Barco increasingly helps in the decision-making process.

The roadmap was made with the Content Value Cycle in mind. The cycle shows that there is room and need for innovation in the interaction area. The way that the target group interacts with the innovations changes over time. The interaction becomes more seamless as the decision making happens increasingly by innovations and less by the imagers. This change of interaction is further explained below and is represented at the top of the technology layer in the roadmap.

Interaction with the innovations

At this moment the radiologist interacts with the working devices through mouse, keyboard and speech. This last form of interacting is processed by NLP, this is explained in the chosen technologies. Among others, NLP is used as the way of interacting in the first horizon.

The ability to process speech is something that is human-like and increases the smartness of a product (Rijsdijk, 2006). This human-like interaction can be built upon and evolved by adding gestures with the hand and body. This evolved version of NLP will be referred to as Natural Vision Processing (NVP) as it captures not only speech but visible movements as well. NVP is used as the way of interacting in the second horizon.

Taking this one step further, the innovation can translate nearly everything a human does in order to communicate. Most important in this interaction is the movement of the eyes, these can be used as a means of input with gaze tracking. Additionally, other forms of communicating could be translated into input. This includes subtle nuances like volume, pauses in speech and other contextual signs. In its most ultimate form, emotion could be included as well. This pinnacle of human-computer interaction will be referred to as Natural Communication Processing (NCP) and it is the way of interacting with machines in the final horizon towards the future vision.

The horizons are explained one by one in the following part.

Horizon 1 - Assisting workflow

This horizon is rooted in the values Certainty, Accessibility and Collaboration. This is done through tools that are integrated in the existing product offerings. Certainty is increased by eliminating faulty diagnoses. Accessibility and collaboration are increased by facilitating sharing between colleagues.

Barco takes the role of the assistant of the radiologist by providing them with workflow tools that support them in their existing role of diagnosing and collaborating with others.

This horizon is focused on enhancing the current design value that Barco offers while preparing the Diagnostic Imaging business unit for the second horizon.

Assistive screens (2020)

The current portfolio of Barco consists of medical displays. These displays will be updated not only in size, resolution or form factor but in their functionalities as well. The screens will have an integrated microphone for dictating as well as a camera for eye tracking.

The screens address the user values of certainty, accessibility and collaboration. The connection with these values is briefly explained in the roadmap in the red rectangles on the user value layer.

Additional to the SpotView and DimView software options that already exist in the monitors, they will be upgraded with workflow tools that assist the imager in their workflow. There are two options for these tools: An 'Eye-fatigue' tool and an 'Auto format' tool.

The Eye-fatigue tool

This plugin recognizes when the imager has been looking at the screen for too long with eye tracking and gives a warning. The diagnostic accuracy drops when the eyes are tired (Krupinski, 2009). Additionally, looking at screens for longer periods of times can cause the imagers eye damage as well (Halpenny, 2012). The tool protects the imagers of these dangers. This phenomenon is confirmed by a radiologist during a meeting after creation of the roadmap.

The Auto format tool for collaboration

This tool formats sent information in a way that is easily readable by the recipient and works with edge AI. Take the example of an imaging study of a patiënt. The imager now and then has to discuss the study with colleagues that are not necessarily imagers. These colleagues might have a different preference for the format of the study and might not even need to see all of the scans in the study. This tool automatically detects the profession and therefore the preferences of the recipient. The tool can then adjust the format accordingly, saving interpretation time and increasing collaboration.

Even though the launch is in horizon two, the development of the 'Advisory platform' starts in this horizon as well. There is a moment somewhere between 2019 and 2021 where there needs to be a critical evaluation of the development of this platform. This is the moment when the development of the platform should begin. The value for the user and for Barco are clear. However, the resources have to be

allocated to begin development in time. Important questions that need to be answered can be seen in the roadmap in the section 'Critical evaluation for further development' that is linked to the service. The Advisory platform is explained more in the next horizon.

There are currently experiments with selling the screens as a service. This is something that will not yet be incorporated in the first horizon. The screens are sold per product and additional services can be bought as well.

Horizon 2 - Advising on diagnosis

This horizon is rooted in the values Remoteness, Certainty, Accessibility and Tech-savvy. This is done through upgrades in the screens and a new service offering in the form of a platform. Remoteness is increased because of the offering of a solution for at home. The platform offers certainty through the algorithms that it provides, it offers accessibility through the overview it provides and it increases tech-savviness by giving the imagers the option to direct imaging techniques.

Barco takes the role of the advisor of imagers. Barco provides the imagers with the confidence to make the correct diagnosis through a service that assists them in directing imaging techniques.

This horizon the focus lies on user-centred value creation and it functions as an essential bridge between the short-term innovations of the first horizon and the long-term innovations of the third horizon. This includes the testing of new technologies or business models in the existing market (Simonse, 2017).

Advisory Platform (2021)

This is a platform that gives an overview of various algorithms that can be used in the work of imagers. The platform is AI based, it learns and operates in the cloud and is integrated in the hospital systems. The platform learns what algorithms are selected for specific studies and can eventually do suggestions based on this information. The platform is open to developers, universities and startups that develop these algorithms. Everyone is free to add their tools to the platform. Users (hospitals) can review and rate the algorithms. After enough uses and reviews, the platform will function somewhat as a mobile app store like the Apple Store or Google Play Store. With enough reviews, the trustworthiness of the algorithms and the platform itself will increase. This amount of reviews is expected somewhere in horizon three.

The platform addresses the user values accessibility, certainty and tech-savvy. The connection with these values is briefly explained in the roadmap in the red rectangles on the user value layer. The position on the roadmap is the earliest possible time for Barco to finish the platform as discussed with the participants of the mapping sessions. The platform is essential for the value proposition of Barco to the imagers. The year 2021 is also the year when innovations from Eizo are expected as derived from the competitive time-pacing analysis in the chapter 'Time planning'. The platform will be paid for as a service with the costs depending on the amount and type of algorithms used. More on the business model in the 'Advisory screens' part.

Flagging

An algorithm that marks areas of interest for the imager. This is already possible but it is not used in practice as the algorithm flags too many areas, ultimately resulting in time loss. The ideal functional and ethical sensitivity for these kind of algorithms still needs to be found. How this is determined according to the receiver operator characteristic curve (ROC curve) can be read in the grey part (Fawcett, 2006). The flagging algorithm itself will not be made by Barco, but the outcome data could potentially be used to improve the algorithm and the platform itself.

Triage

This algorithm does not help in diagnosing but it helps in prioritizing the cases in order of urgency. With this application, the cases that need the most attention get processed first. The amount of incidents related to long waiting times will drop drastically. This application could be made by Barco. This is because there is no need to access a detailed report of the patiënt information. The only data that is needed for a basic version of this application is a description of the symptoms. This relatively low amount of needed patiënt data makes it easier to reason for such an application.

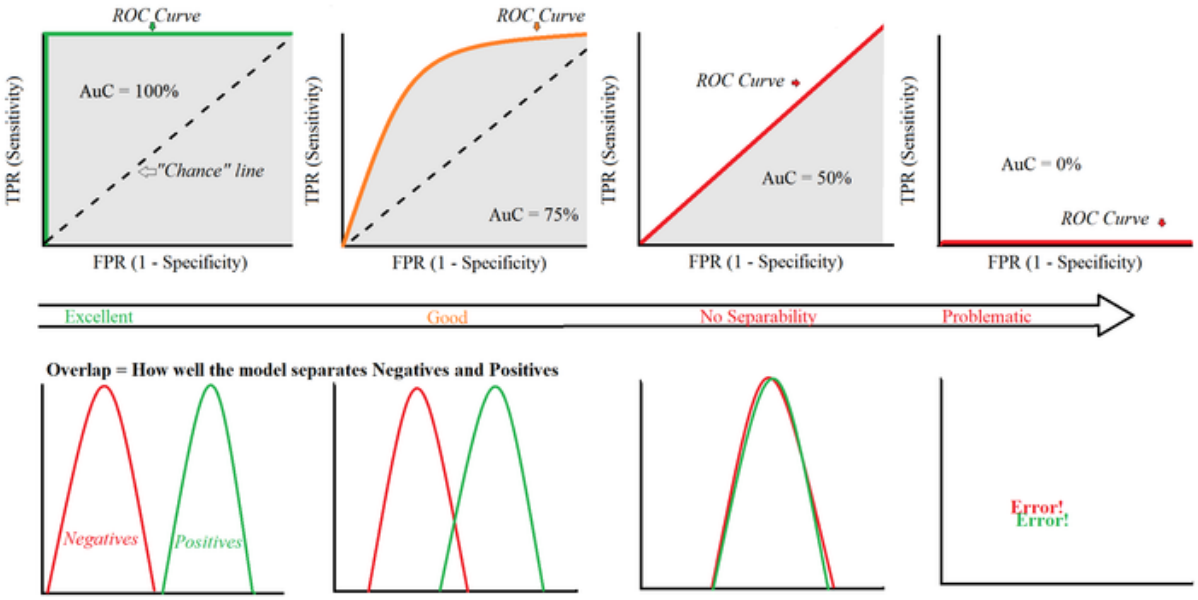


Figure 34 - ROC Curves explained (Glen, 2019)

This is essentially a ratio between the number of true positives compared to the amount of false positives for every sensitivity setting. With too low sensitivity there are too many cases that get past the system. The ROC curve is explained in figure 34. With too sensitive settings, the number of flags becomes so large that there is too much time loss. This dilemma is rooted in ethics as well: How much time per patiënt is too much time when it concerns human health? These kind of questions still have to be answered.

Advisory Screens (2022)

Accompanying the platform is a new series of screens that are labelled as Advisory screens. The screens bring an extra form of interaction as a possibility: gestures and hand movements. This is a step towards a more human-like and seamless interaction than the last generation. Additionally, with the amount of possible interactions growing, so does the perception of multifunctionality, reactivity and cooperation of the system. This will improve the human-likeness even further (Rijsdijk, 2006). Further improving the seamlessness, the screens can be used at home as well. The goal of this is that the imager can perform diagnosis from home instead of only giving a second opinion or screening. This brings a lot of new demands for the screens as the situation at the imagers' homes varies greatly. Many variables can influence the accuracy and speed of diagnosing. These can be technical, such as the lighting in the room or noise around the imager, but they can also be social or emotional. These variables need to be mapped thoroughly before investing heavily in home screens.

Recommendation: The technical variables can already be measured via camera and microphone. In case of too much distraction or external influence, the screen can give a warning message to incentivize the imager to reduce the amount of distraction. The downside of such a system is that the imager might feel trapped behind the screen, ultimately leading to decline of the product.

The screens address the user value of remoteness and build upon the user values of the previous horizon. The connection with remoteness is briefly explained in the roadmap in the red rectangle on the user value layer.

The screens are no longer sold as a product in a pay-per-product business model. Instead, the screens are sold as a service. The hospitals pay for the screens on a subscription basis and in return they can receive service in case of problems, QAWeb, the Advisory algorithm and other benefits. Hospitals can

choose which of these elements they would like in their service with the most basic version being the screen itself and the warranty service.

Even though the launch is planned for horizon three, the development of the 'Co-piloting glasses' starts in this horizon. There is a moment somewhere between 2021 and 2024 where there needs to be a critical evaluation of the desirability, feasibility and viability before development of this innovation can begin. If the innovation does not meet the set requirements at that point in time, the project might be declined and resources might be allocated elsewhere. Important questions that need to be answered can be seen in the roadmap in the section 'Critical evaluation for further development' that is linked to the innovation. The Co-piloting glasses are explained more in horizon three.

Horizon 3 - Co-piloting care

This horizon is rooted in the values Remoteness, Certainty, Collaboration and Tech-savvy. This is done through upgrades in the screens, the platform and the launch of glasses. Certainty is increased through peer reviews on the platform. Tech-savviness is increased through giving imagers more choice in the screens. The glasses realize remoteness by removing the need for a screen. It realizes certainty by facilitating an extra expert view on a surgery. It facilitates collaboration through the effectiveness in surgery applications.

Barco takes the role of the co-pilot of imagers. Barco provides imagers with a seamless experience while diagnosing, directing and collaborating through communication and viewing tools that are easy to use and are connected to each other.

The third horizon focuses on a new value proposition. This horizon has the possibility to disrupt the first strategic life cycle and the future vision is the end point of this horizon. This horizon proposes a new business model that has to be tested in the second horizon.

Co-piloting platform (2024)

This platform evolved from the Advisory platform but the value proposition differs greatly. The platform does not only advise the imager but it acts as a co-pilot. The algorithms on the platform can perform tasks that are otherwise performed by an imager. Apart from the algorithms, the platform itself has transformed as well from offering an overview of the available algorithms to a platform that gives suggestions on what algorithms to use. Additionally, many hospitals have rated the algorithms on their accuracy for different use cases. In this way, the platform becomes one that co-pilots as the decision-making shifts further towards the innovations.

There are a few important variables that must meet a critical amount in order for the platform to become 'co-piloting' and add value: user base and content. The platform needs a minimum number of users for multiple reasons. The developers of the algorithms prefer a large number of users for their revenue and deep learning process. Furthermore, the user base gives the reviews to the algorithms. A minimum of users is needed to make the review system trustworthy. Additionally, there needs to be a minimal number of algorithms as content. Without enough content, the full value of the review system is not gained as there is too little choice between the algorithms. Not to mention that the hospitals might reject the platform because there are not enough options to choose from.

An example of an algorithm that could be on the platform is 'Second opinion'. This algorithm acts as a co-pilot for the imager.

Second opinion

For almost every case in radiology there is a second imager that gives a diagnosis. This is done to reduce the overall error rate. However, this is very time consuming and costly. This algorithm is able to give a second opinion. Take note that this is a second opinion and not a full diagnosis done without a human.

Co-piloting screens (2026)

These screens bring yet another improvement to the interaction. The imager can not only control the screen with their voice and gestures but with their eye movements as well. This is the screen on which the imagers use the Co-piloting platform. Therefore the complete experience must feel like the most seamless working experience. To further increase this, the screens offer the option of modularity as well. How the modularity is a huge benefit is explained below.

The screens address the user value tech-savvy. The connection is briefly explained in the roadmap in the red rectangle on the user value layer.

Modular screens

These screens have the option to be custom made for a relatively low price. The screens are modular, which means that the imager can decide on the size of the screen. Additionally, the imager can later upgrade the size of their screen. Furthermore, when a screen is broken, only the broken part needs replacement.

Co-piloting glasses (2028)

These glasses are essentially a head mounted display (HMD) that is very small compared to the HMDs that are available today. These glasses are not invasive for the imager because of the size, the weight and the ability to be transparent. The glasses can be compared to the glasses that Google launched in 2012. Google took the functionality of a smartphone screen and transformed this into a wearable device that resembled glasses (Goldman, 2012). The Co-piloting glasses will not show scans of the patient. Instead they show a live feed from a surgery where a co-pilot is needed. The imager can provide guidance with real-time diagnosis during a surgery. This can happen outside of the operating room. Additionally it can provide patient information like patient history, family information, schedule of treatment, etc.

The Co-piloting glasses address the user values of remoteness, certainty and collaboration. The connection with these values is briefly explained in the red rectangles on the user value layer.

These are the innovations for Barco to do in order to get to the desired future. The combination of all of these products makes for an experience that is meant to be so seamless that it feels like a co-pilot helps the imager with their tasks.

The business model for the second horizon was based on paying for the screens and platform as a service. For this horizon the business will be the same initially. However, in time there might be a change in a different business model. As the complexity rises in patient care, there might be a point where care is expressed in a number. This would be done to reduce complexity as well as creating a universally understandable value that patients pay for. This increases transparency and it facilitates equality between patients in costs of care. This new business model, Care as a Service (CaaS), will have to be evaluated and experimented with in Horizon 3.

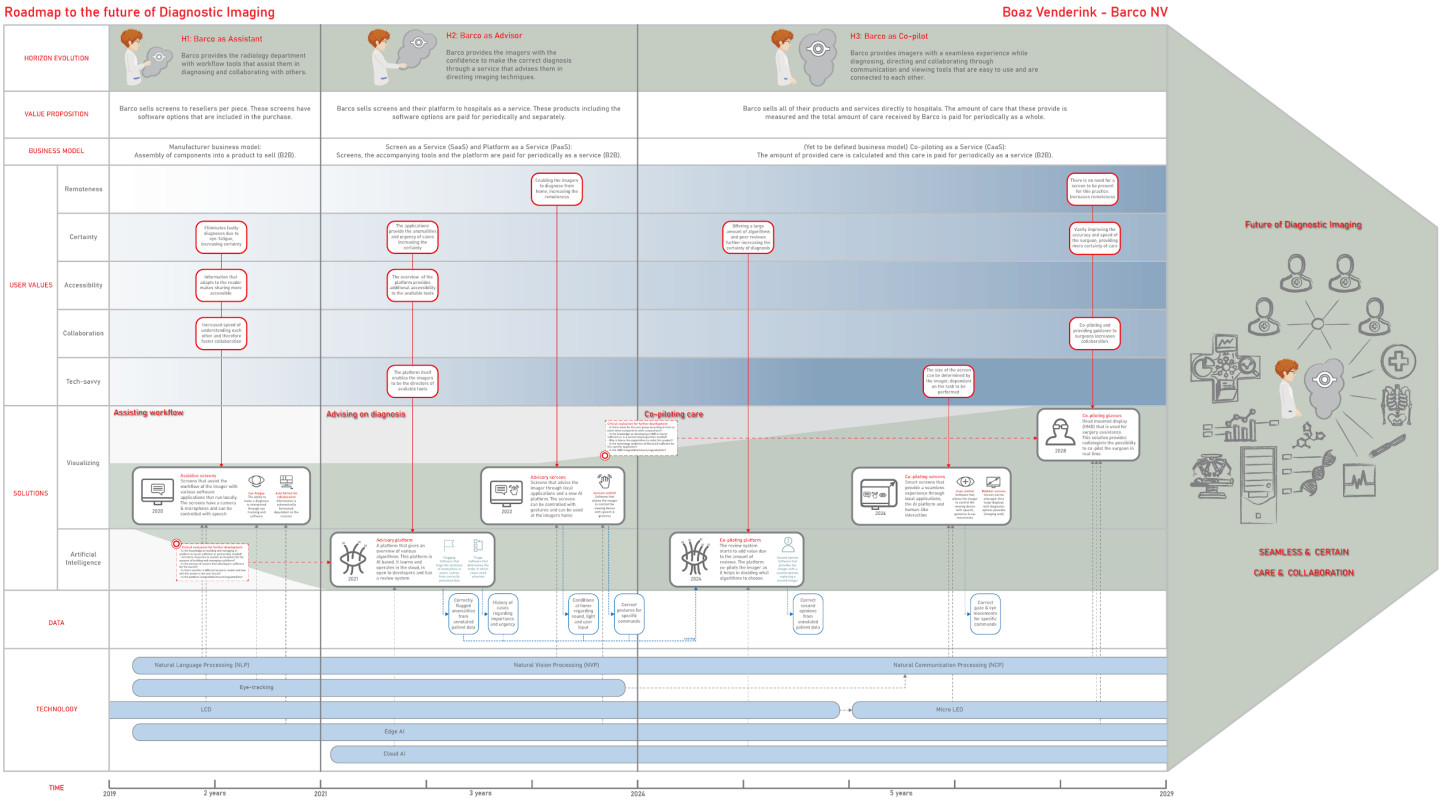


Figure 35 - Roadmap

Previous roadmap designs can be found in Appendix H.

User feedback

One of the radiologists that was interviewed during the value mapping phase agreed to discuss the roadmap in an informal setting and share her thoughts on the work (see the picture below).

The feedback was very positive as she could relate to the user value layer. The innovations were clear and showed a logical evolution. There were some improvements to be made as well:

- There could be innovations in the area of integrating systems as well, this is not included in the roadmap.
- The cloud that the imager holds is dark grey, suggesting something negative
- The future vision could use a visualization like the evolution of the horizons

These changes were incorporated in the final roadmap.

Conclusion

The roadmap shows that the proposed solutions (services and products) are rooted in the five value wishes that were chosen as the most relevant. It also shows an evolution in multiple ways. An evolution in the role of the radiologist who becomes an imager. An evolution in the interaction of the imager with the products and services that they use. Most importantly, the roadmap shows an evolution in the value that Barco brings to the imager. The role of Barco changes from an assistant to an advisor and finally to a co-pilot in delivering care to patients.

In addition to staying relevant to the user, Barco has other strategic directions that have to be accounted for. There were three additional goals according to the 'Project Direction' part that concluded the context analysis. One of these goals for Barco is to expand their offering to interaction and process & control instead of only visualization according to the Content Value Cycle. This is something that is realized from the first horizon in the Assistive screens through workflow tools that improve interaction. This continues in the second horizon with additional tools in the Advisive screens and the Advisive platform that is essentially an end-to-end service (capturing all quadrants of the CVC). In the third horizon this continues in the screens and in the platform. The Co-piloting glasses also provide interaction through collaboration. Additional to the offering of the products and services, the manner of interacting with these evolves into Natural Communication Processing further adding to the value that Barco offers.

The other goal for Barco is to have products and services that reside in the the full height of the 'Value stack' as explained in the part 'Innovation strategy' from the context analysis (figure 6). This value stack shows that the full value of a market is grasped when there are products and services in each of the four layers. The solutions on the roadmap provide assistance for 'Workflow' like the tools in the screens as well as 'Analytics and Insights' through the use of the evolving platform.

The final goal that was formulated is testing the solutions on desirability and viability early in the process. These moments have been incorporated in the roadmap with relevant questions.

Implementation

A design roadmap can have multiple goals. It can increase customer awareness, create market differentiation, better time-to-market or overall better competitive advantage (Simonse, 2017). These are all effects that may be reached by following the method. However, the main reason for Barco to embark on such a project was to explore the world on the outside. The goal was to focus on the user and on the market instead of on the organization or technologies. The core competences of Barco are technical and there was a need to confirm the technical innovations with the user side of the story. Additionally, this exercise was done to look further in the future than usual. There have been moments when future innovations were expressed, but always on an abstract level and never in a concrete way.

The goal of the final design roadmap itself is threefold: to inspire people, enable conversations and to give overview. The roadmap might inspire people in what values of the user are mentioned, what innovations are used to fulfil these values or simply the evolution in value proposition. The roadmap gives a visual overview that is comprehensive and understood by all of the employees in Barco. It can be used for referring back to when in a future situation. The most important use for this roadmap in this specific project is to enable conversation between the management of Barco healthcare and R&D. This roadmap is a combination between a strategic roadmap for senior management and a tactical roadmap for R&D. There is enough detail for R&D to gain insights and discuss. On the other hand there is strategic positioning and evolution for the management to gain insights and discuss.

There are more and less effective ways for the roadmap to be implemented in the business unit. As it concerns the future for the whole team of diagnostic imaging, the roadmap would best be examined by all people of the team at some point. Many of the engineers and managers in Diagnostic Imaging or the Technology Centre already have knowledge of this roadmap. They will relate more easily to the roadmap itself and to the implementation of it.

At the ending of this project I will present my findings at Barco. For this presentation to have the most effect it is important that the audience is quite broad. Preferably there are not only people from senior management but product managers, engineers and marketers as well. This will increase the chance of the roadmap being championed and carried out further in the company. Furthermore it creates a collective understanding of the roadmap and facilitates discussion between different layers of the company.

After the presentation, everyone in the audience is given a print of the roadmap and the accompanying explanation. This is done to increase the understanding of the roadmap by the audience after the presentation but mostly for them to be able to explain it to others who have not seen the roadmap yet. These files are available digitally as well for the purpose of easy sharing.

The roadmap can then be followed in time and serve as a guiding principle. The focus should lie on the evolution of the value proposition and the values of the target group when regarded by the management. The values have to be monitored carefully as any change in one of these might have implications for the innovations on the roadmap. Additionally, the evolution of the value proposition and Barco's role towards the target group has to keep its fit with the other business units in Barco Healthcare. For this reason it is crucial that if the roadmap is indeed executed, the other business units of Surgical Imaging and Custom Modality have to be involved, as well as the management of Barco Healthcare.

For the engineers, the focus should lie on the user values, the technologies and the innovations that arise from these. The connection between these layers is mostly important. The user value and technology layers can change over time and therefore might have implications for the innovations on the roadmap. Constantly validating the user values, technologies, business models and timing along the way is crucial when following the roadmap.

Recommendations

First, the limitations of this research will be discussed. Hereafter, the recommendations for Barco are stated as well as academic recommendations regarding the methodology of Design Roadmapping.

Limitations

There are a few limitations to this research that have to be clear when reading this thesis. These limitations may have implications for the follow-up on this project or the implementation.

First, the project was focused on Western-Europe from the beginning. Advancements from other parts of the world in markets or user values have not been considered. During the time at Barco, other markets were mentioned as opportunities but these were left out of the scope deliberately. This roadmap can only be used for the market of Western-Europe. Which brings us to a related limitation: All of the interviewees were from Belgium or from the Netherlands. For a truly Western-European research, more nationalities will have to be explored as well.

Secondly, this project focused on the existing business of Diagnostic Imaging. There were project proposals related to other markets like dental, ophthalmology and pathology. However, these were not considered as the main user of these markets is not referred to as a radiologist. By focusing solely on the radiologist, the scope was narrowed down and this made for a more 'specialized' thesis. However, broader implications for the field of 'Imaging' are not addressed.

Third, the project did not include the possibility of partnerships and acquisitions as stated in the project brief. Including this option might have changed the roadmap significantly. The impact that a partnership or acquisition would make has to be explored more closely as well.

Fourth and last, this project was mostly executed individually except for a session in pattern creation in the value mapping phase and the two sessions of idea mapping. Ideally, the design roadmap is made by multiple people to increase discussion and reduce bias. Additionally, this would provide extra championing power in the organization.

Recommendations for Barco

In addition to making the roadmap, there was a second goal in this project. This graduation assignment is also used as a means for exploring the relevance of design roadmapping for Barco. Before conclusions are drawn, roadmapping would always be an exercise that is worthwhile doing. However, in regard to timing, costs and available people it might be more effective to allocate resources elsewhere. That being said, there are multiple characteristics of Barco and their business that have implications for design roadmapping.

Design roadmapping proves to be a great tool in exploring the values of users. This happened quite extensively in the Value mapping phase of the process. This is also the part that has added the most value for Barco and it is one of the main reasons for this project to be created in the first place. However, the healthcare market is a complex one. This market has many stakeholders that are situated in many different layers of different organizations. For example: when an product is to be launched, not only the user (imager) determines the value of such a product. In this case, the ultimate value has to be proven by the patients, the hospital has to make the purchase and the imager has to work with it. This creates a very complex system in which it is hard to determine how a product will perform. For the method to be the most effective, the values of other stakeholders like the patients, the hospitals and even governmental organizations have to be mapped as well.

In addition to that, Barco does not sell its products and services directly to the users but always through a different organization (B2B). This makes Barco dependant on these organizations to some extent. These organizations, called channel partners, are not only customers but they are competitors as well. In such a system, not only the values of the users can be regarded but the values of all partners in between have to be taken into account as well.

The complexity because of these factors make it difficult to efficiently perform the design roadmapping method. It may take a disproportionate amount of resources to map all of the values of the stakeholders that are involved in the process.

My recommendation for Barco is to talk with users frequently to be able to maintain a competitive advantage. The focus should be on the value mapping stage of the process as the company already has a lot of experience in mapping technologies. For every market that Barco operates in, there should be a key user that is involved in the strategic meetings. In addition to that, the various business units could use a ‘market expert’ that keeps track of the developments in that specific market. This expert could interview users and watch trends that have implications for the business unit. With such functions in the team, the process of trend patterns is followed albeit in a simplified manner.

Academic Recommendations

Design roadmapping in a technologically focused company proves to be very valuable. The nature of the process, being user-centred, is something that can be forgotten over time in such a company. However, the entire process of getting to a roadmap is one that is extensive and would take a lot of resources and time from the company.

For companies that do not have the resources to spend I propose a shortened version of roadmapping where the focus lies entirely on the future vision and the evolution of that vision. Within a business unit, the value mapping process can be followed until future value wishes have been found. Then, in a session with users and engineers, the future vision can be formed and the evolution of this vision imagined. The idea mapping and Pathway mapping are left out of this process. This will still have a huge impact in a technologically focused company while saving time and resources.

The use of design roadmapping in a healthcare context is very different from a market that has its roots in design or any other form of aesthetics like automotive or fashion. This is due to various reasons. First, the evolution of innovations is clear to see through visual cues. This is something that is less true for the healthcare market, where functionality and business models are more important. Secondly, these companies often sell directly to users. This makes it easier to see their values and the innovations can be addressed to them specifically. Third, timing in the healthcare market is strongly related to regulations and legislation which makes it hard to plan innovations on a timeline in the future. The regulations might also make certain innovations obsolete in a way that is hard to predict.

Regarding design roadmapping in a B2B context: there might be value in an expansion of the methodology by mapping the different stakeholders in an overview before the value mapping phase. This might make it easier to see connections and implications when making choices. In this overview, things like the needs, challenges, do's and dont's can be explored per stakeholder. Then the interaction between these can be visualized in a comprehensive overview that can be referred back to at any time in the project.

Appendices

A: Interviewing preparation

Before the interview

The first step is to find the people to interview. These are found according to a well-defined sampling method that is described in the following part.

Sampling method

The goal of the sampling method was to get a group that is the most representative for the future radiologists. The sampling technique is purposive, representative for a specific group of people in the society, as the interviewees will be thought leaders on the subject (H. Caspersen, personal communication, 22-4-2019). Multiple-case sampling is used as well. This technique is used to look at similar and contrasting cases to be able to understand a single-case finding, in this case a future vision (Yin, 2009). For time-constraints it was not viable to speak to that many radiologists to facilitate complete comprehensive sampling, examining every case in the radiologist population (Goetz, 1984).

Two steps for sampling:

- Set boundaries (Radiology department, a maximum of five interviewees per cycle)
- Frame
    - Workflow of the radiologist (from beginning to end of the day)
    - Zoom in afterwards into specific part of the workflow
    - Future expectations
    - Compare the current workflow to the future workflow

Sampling parameters

- Settings: Hospital, Private clinic, (other care institutions)
- Actors: Radiologists, people that collaborate with radiologists (other care professionals)
- Events: Complete workflow – e.g. Getting at the desk, booting system, selecting software and starting programs, determine work to do, first patient diagnosing, typing down comments/diagnosis, communication with other systems/people, moving to the next patient, … , finalizing day, shutting down system, leaving work)
- Processes: 'Everything mentioned in the events', zoomed in on the actual 'work' of the radiologists while avoiding tunnel vision (H. Caspersen, personal communication, 22-4-2019).

To ensure that the interviewees have variation between them, there was a selection based on a couple of variables:

- Age
    - just starting the profession
    - already working a few years
    - almost retiring
- Specialization
    - Mammography
    - Abdomen
    - Interventional

- Echo
- etc.

Including people that are younger and that have just finished their studies is done because of several reasons:

- The interviewees still have a lot of knowledge about the field of radiology from the university. The rather new techniques are still fresh in the mind and there is a chance that they have learned about their future profession.
- The interviewees did not yet form a strong opinion on a specific future due to extensive experience in a sub-part of the radiology profession, making them rather unbiased.
- The interviewees will have to cope with the future since they are just starting, thus making the interview relevant to them accordingly. (Radiologists that are going to retire soon can have less interest in the future since they will not be radiologists anymore in the near future)

Preparations before the interview

Before interviewing it was important to know some of the jargon and expertise of the interviewees so that I did not come across as someone who knows nothing about the subject (P.J. Stappers, personal communication, 29-5-2019; H. Caspersen, personal communication, 22-4-2019). The interviewees were informed about the project and the project goal before the interview (P.J. Stappers, personal communication, 29-5-2019). A list of possible codes that could be mentioned by the radiologists was made beforehand, this made for easier analysis and a quick way to write insights down and index them. Permission was asked to record the audio of the interview for later revisiting in case anything got lost in conversation. The interviewee was explained what answers are wanted at the end of the interview (P.J. Stappers, personal communication, 29-5-2019). If it was possible, the interviews were conducted at the places where the interviewees work.

During the interview

The answers to the questions were not written down for two reasons. Firstly, because the interview was recorded the answers can later be written down or typed out. Secondly, it was possible to react on everything in a more engaged fashion without having to write things down constantly.

Talking about the past

When asking about the past, a 'hero story' was the perfect subject of conversation. A hero story is a situation that went horribly wrong and the interviewee solved the problem anyways. These stories contain problems that the interviewees encounter, the interviewees like to talk about these situations and the interviewees remember these moments well (P.J. Stappers, personal communication, 29-5-2019). This method is used for some of the interviews.

Talking about the present

Using a timeline of the interviewees day is great for exploring the present. To get the amount of information that is wanted, a large sheet of paper with the distribution Past/Present/Future was used for some of the interviews. Everything the interviewee says will be written down in one of the three sections. In this way, it becomes visual for the interviewees what to talk about more (L. Sanders, personal communication, 21-5-2019).

A value chain from the HC market from Barco to the patient was shown in several interviews. The interviewees could then fill in the missing links between hospitals and radiologist. This was meant to make them think of the bigger picture and triggered them to tell more about what forces and values act in this ecosystem. The used value chain is shown in figure 36.

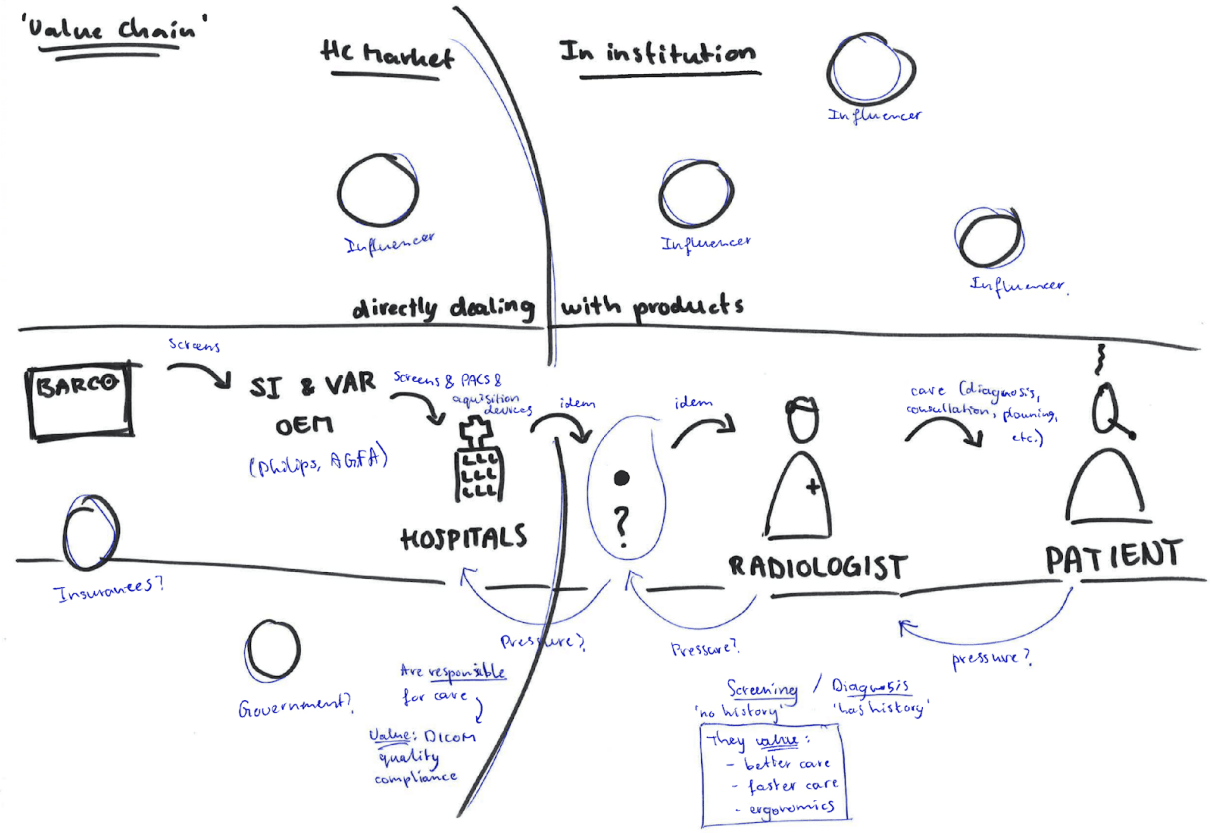


Figure 36 – Value chain

Talking about the future

The interviewees were asked about their vision of the future. During the process, wishes for future innovations are stated and these are articulated explicitly. People's passions, desires and aspirations can be framed as future visions. The vision captures a value wish. "Value wishes express a desired end-state in which a novel value fulfils an unmet need or resolves a present dilemma experienced by the target group" (Simonse, 2017).

When asking about expectations of the future there is a fundamental difference with interviewing about the present. The interviewee has no experience with the future. This makes the answers of the interviewees subjective and dependant on the interviewee. However, some methods have been described that elaborate upon interviewing for future needs. These methods and the advices from the three experts were used in talking about the future. The two most important methods, the 'path of expression' and 'laddering' are explained below.

- Path of expression

Defined by Sanders & Stappers, this is an order in which talking about the future is facilitated. This specific order of execution facilitates thinking about the future. First, interviewees think about their

current experiences. Then they relate it to their past. After this, they reflect on the memories and present. Finally, the interviewees can express future experiences. "It enables people to connect to what is meaningful from their past and present experiences, using that as a springboard for ideation about the future" (Sanders, 2016). The method enables the interviewees to see the connection between the past and the present. This same way of thinking will then be used in connecting the present and the future. An overview of the path is illustrated in figure 37. The numbers in the figure are explained below.

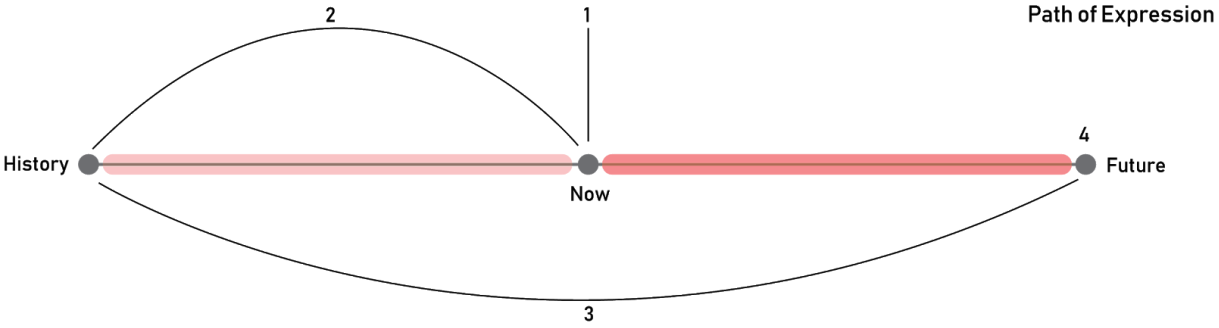


Figure 37 - Path of expression (Sanders, 2016).

It describes how a jump to the future might be facilitated when following the four steps:

1. Current activities
1. Earlier experiences
2. Reflect on those memories and possibilities for the future
3. Express future experiences

Another used method is laddering, this is explained below.

- Laddering

Laddering is moving up and down in an abstraction hierarchy. Going up by asking 'Why' and going down by asking 'How'. When asking interviewees about current/past experiences, these experiences can be condensed to a value or a set of values by asking why until a value is reached. When asking about the future the same is done; interviewees articulate their future wishes for innovations. These can then be translated into future value wishes by moving up on the ladder (Sanders, 2016).

When making a roadmap after the future vision, the direction is more or less reversed. The future vision contains a set of values, these can be translated into more concrete and actionable innovations by going down the ladder. The actionability and abstractness of information in the consumer market is described by van Kleef et al. in 2005. The highest level of abstraction being the consumer values and the lowest level the product characteristics. This is visualized in figure 38.

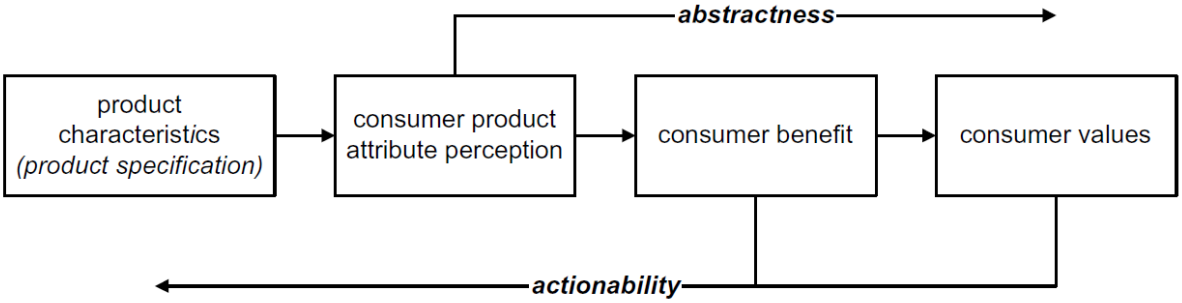


Figure 38 - Actionability and abstractness of provided information (van Kleef, 2005).

Below is a famous quote by Henry Ford and a perfect example of a difference in level of abstraction. By moving up in the abstraction hierarchy, the underlying values of the people were understood and the car was born.

"If I had asked people what they wanted, they would have said faster horses."

– Henry Ford

To incentivise radiologists to talk about the future, trends can be proposed. However care is needed not to point the interviewees in a direction. To avoid this, two sides of a trend or vision can be shown. Quotes can be used as well by asking if the interviewees agree or that they do not (H. Caspersen, personal communication, 22-04-2019; L. Sanders, personal communication, 21-5-2019).

B: Invitation e-mail for the interviewees

Beste NAAM,

(Via NAAM ben ik naar u doorverwezen)

Ik zal mij kort voorstellen: Ik ben Boaz, een masterstudent die op dit moment afstudeert aan de faculteit van Industrieel Ontwerpen aan de TU Delft. Mijn afstudeeropdracht betreft het maken van een roadmap naar de toekomst voor het vakgebied van radiologie. Voor het maken van deze roadmap is het uiteraard van het hoogste belang dat de inzichten van de radiologen worden meegenomen.

(Dit zou ik graag doen door middel van observeren/meelopen, gevolgd door een interview)

Nu is er al een analyse gedaan door mijzelf, dit is echter vanaf mijn invalshoek als inginieur gedaan en het is lastig om voor te stellen hoe de invalshoek vanuit de radioloog is. U heeft ervaring in het vakgebied en u zou me enorm kunnen helpen met mijn onderzoek.

Heeft u aankomende week de tijd (voor het observeren en) om hier samen over te praten?

Ik hoor graag van u terug en mail gerust als er nog vragen zijn.

Vriendelijke groet,

Boaz Venderink

C: Instructions for the clustering

Goal

The goal is to cluster these insights to gain an understanding of what the values are of radiologists, how trends connect to those values and how the future is formed through the trends.

END GOAL FOR ME: Using these clusters to determine what the future is of radiology and how things change between now and the future.

I will help with the timing of the specific things!

Legend and terminology

------ = Important value in radiologists work

------ = Trend that is going on

------ = Future vision

------ = Challenges to overcome to future

AI: Artificial Intelligence

Annotated: Confirmed that the diagnosis was the truth

DI: Diagnostic Imaging (Diagnosing by interpreting images)

EHR/ EPD: Electronic Health Record (digitalized file of patient)

FDA: Approval to produce and sell the product/service

PACS: Picture Archiving and Communication Systems (software where the radiologist sees the pictures)

PPP: Public Private Partnerships (Radiologists that sell themselves as freelancers to diagnose scans from hospitals)

Protocolling: Reporting on the diagnosis of the patient

Value based healthcare: Patient pays for the outcome, not the quantity of the care

VNA: Vendor Neutral Archive (centralized EHR, useable for all health providers)

D: Value mapping process

Cycle 1

Desk research

Academic

Individual work, judged as organization
Discrepancy between radiologist used to work as individual and more and more judged as an organised whole (Kruskal, 2018).

AI: research priorities
Roadmap for research on AI concludes multiple research priorities:

- Image recognition methods
- Automated labelling and annotating
- New machine learning methods
- Explainable AI (explaining the advice to humans)
- Validated methods for de-identification

(Langlotz, 2019)

Social Media

No focus on patient

"There is not enough research compared to other fields in HC. Tech-based companies research the field but without focus on the patient" (Clarke, 2019).

AI: screening, Triage and Prioritization

Biggest AI impacts: Screening, Triage and Prioritization (Harvey, 2019).

Growing complexity

"Keywords for this era: Growing complexity; because of the massive increasing stream of data, not only in hospitals but also at home" (Rubens, 2018).

News

Increase in communication with patients and colleagues

"There is a change to value-based HC where the client pays for the value of the care instead of the quantity. In order to keep up with the changes, physicians need to: Know their customers, Communicate, Pursue teamwork among other qualities. These suggest that communication with patients and colleagues will increase in either quality or quantity" (Palmer, 2019).

Psyche of patiënt important

"A substantial amount of successful patient outcomes has to do with the psyche of how patients approach healthcare, how they feel during their healthcare encounters, and how they prepare themselves for the encounter. It matters just as much as what they experience during the encounter and afterwards" (Palmer, 2019).

5 trends in Health IT

- Enterprise Imaging Adoption for Radiology is Set to Continue
- New Revenue Opportunity Increasing, Fuelled by Emerging Markets
- Enterprise Imaging is Having a Greater Influence on VNA
- Operationalized Sales Models Are Gaining Traction, Slowly
- Opportunities for Standalone Universal Viewing Will Diminish

(Holloway, 2019)

Interviews

Sampling

The first cycle was used to gain a lot of connections in the radiology field. However, the contacted radiologists have very busy schedules. Thus for this cycle only one radiologist was interviewed.

Interviewee: Olivier Vanovermeire (CMO of Barco, Head of Service Radiology AZ Groeninge, Radiologist)

Put image of interviews

Insights of interviews

The insights from the interviews are divided in values of the radiologist, trends and future vision.

Interview Olivier Vanovermeire

Values:

- Developments should be used for better diagnoses, contact with patient and contact with referrers

Trends:

- Patients have become more assertive and knowledgeable
- Complexity of the scans increases, radiologists involved in treatment more and more
- System is getting more patient-centred
- Clustering of hospitals in Belgium and Europe

Future:

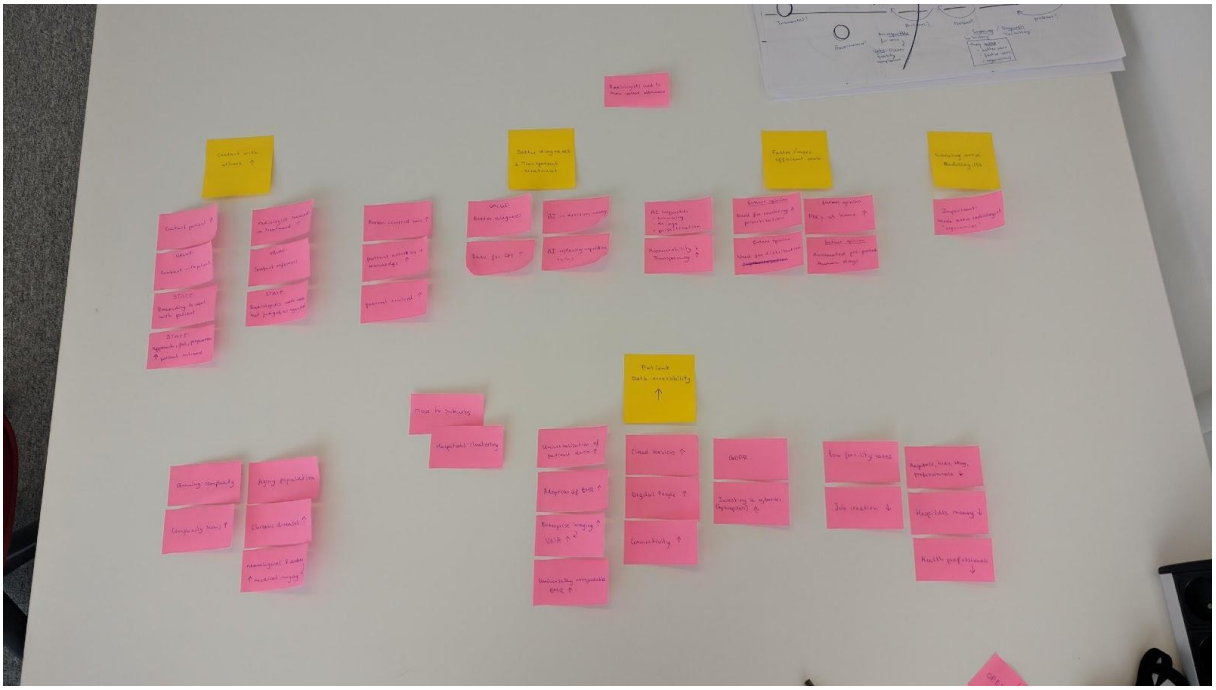
- PACs stations at home of some radiologists, this will increase
- Need for the distribution of cases to the most relevant radiologist for that case
- Need for ranking cases on importance in the workflow
- Automated pre-protocolling might happen but always human validation

(O. Vanovermeire, personal communication, 23-4-2019)

Future visioning

The first future vision mostly had input from trends as there was only one radiologist interviewed. However, during the clustering it became apparent that there are certain future directions can be supported.

The clustering process can be seen in images 18 to 20. The pink notes are insights from trend research and the interview. The yellow notes are the clusters. The main value of the radiologists is the 'quality' of their work, the 'efficiency' and the 'workplace' ultimately lead back to the 'quality'.



Images 18-20 – Clustering process of first cycle

On the one side the need for services of the radiologists will grow through complexity and expected increase of patients. On the other side, radiologists are scarce and hospitals have fewer resources. This creates a need for more efficiency of the radiology department.

There is an increase in the use and the accessibility of patient data, not only by health providers but also by the patients themselves. This creates a certain transparency that is required from the care providers as to what happens in the process of care. Patients will require feedback and insights in their care continuum and other medical specialist require integration of the radiologists work into the process of curing the patient

This will drive the need for radiologists to communicate more with both the medical professionals and the patient. Additionally, this drives minimally invasive procedures as appropriateness of care is not only determined by the radiologist but by others as well.

In conclusion, the first future vision: The radiologists work will require more communication and integration with medical professionals as well as communication with patients.

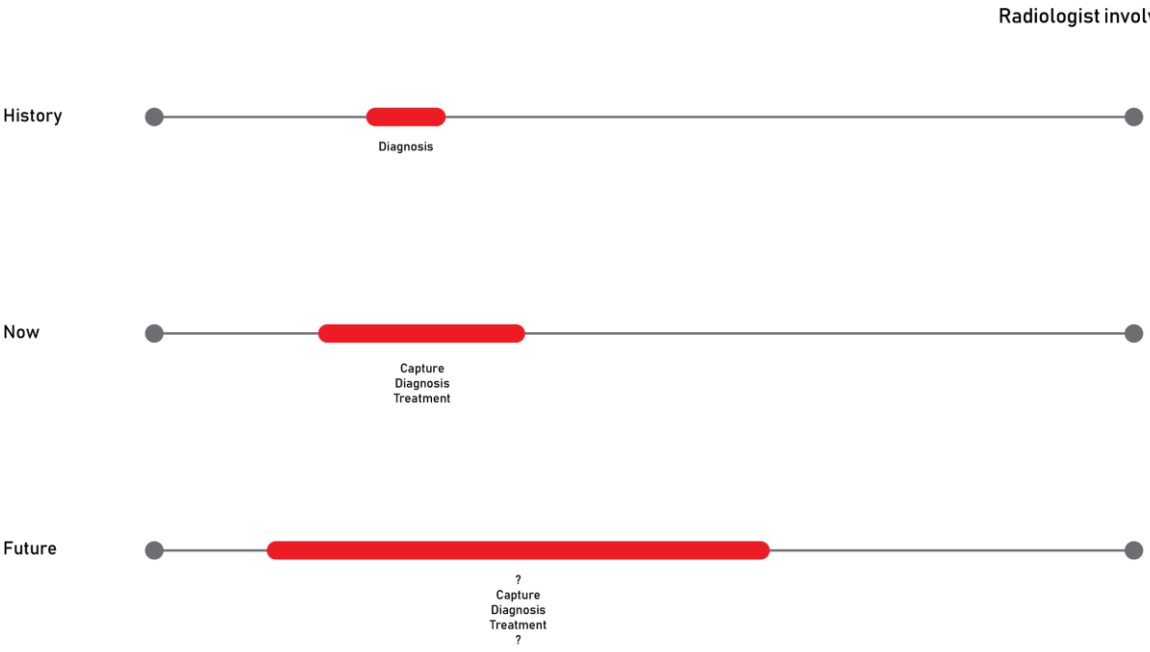


Figure 39 - Involvement of radiologists

The involvement of radiologists according to the clustering is illustrated in figure 39. Radiologists used to be purely involved in the diagnosis. Nowadays, the work involves capturing the data in certain cases and co-deciding on the treatment or even treating patients with interventional radiology. Their role is expected to grow even broader in the care process. Some possibilities are increased contact with patients before and after diagnosis (intake, consulting, coaching, prevention), increase in treatment decisions (interventional radiology, surgical assistance, treatment planning). However, how the role will evolve is not yet clear at this point in time.

Learnings

The first future vision paved the way for the coming cycles, it provided valuable insights and created a general understanding of what is happening in the healthcare market. There are however critical learnings that can be derived:

- Make contact with the interviewees ahead in time. Radiologists have busy jobs so the interviews need to be planned at least two weeks in advance.
- Introductions through other people work very well in inviting people for interviews.
- Plan extra time for gathering insights and clustering as it may take a long time to do so.

Cycle 2

Desk research

Academic

Radiologist is no order processor but partner in team-based patiënt care

“Radiologists should not be equated to a laboratory test to deliver results, in which radiology studies are simply deemed an “order” by the referring physician. Radiologists would benefit from consultation clinics because it would add additional meaning to their work. It also improves relationships with referring physicians who should view radiologists as consultants and partners in team-based patient care” (Patel, 2019).

Deep learning & Radiomics will unify

“Deep learning and radiomics are two rapidly advancing technologies that will unite in the future to produce a single unified framework for clinical decision support with a potential to completely revolutionize the field of precision medicine” (Parekh, 2019).

Radiologist work 2013

“Radiologists spent 36.4% of their time on image interpretation. The proportion of non-interpretative tasks was 43.8%. Total clinical productivity was 87.7%, and radiologists experienced, on average, 6 interactions per hour with other health personnel, of which over 81.2% directly influenced patient care in real time” (Dhanoa, 2013).

Preferably only one radiologist to interpret scan

“Both radiologists and referring physicians prefer to have a single radiologist read an image and communicate their findings in a single report for a multi-part CT scan to avoid ambiguity” (Yin, 2019).

News

Expectations for AI: reduce errors, cutting times, more time with patient

In research among 270 French radiologists, 81% said their highest expectations for AI’s positive impact involve reducing imaging-related medical errors. This was followed by cutting image-interpretation times (74.4%) and increasing time spent with patients (52.2%) (Pearson, 2019).

Adoption of EMR

Adoption of Electronic Medical Records (EMR)/Electronic Health Record (EHR) systems has increased globally (Mothgare, 2019).

Universalization of medical image data

“The vendor neutral archive (VNA), has replaced PACS in some healthcare settings. Increased demand for universalization of medical image archiving and storage of all formats of medical data is expected to fuel PACS market growth during the forecast timeframe” (“Picture Archiving”, 2019).

Increase in minimally invasive procedures

“The growing demand for the safety of patients and less incision has led to a rise in the number of minimally invasive procedures that have been carried out which in turn is boosting the medical grade display market across the globe” (“Medical Grade Display”, 2019).

Growing neurological and cardiac issues

“Demand for medical imaging services is on the rise due to growing incidence of neurological and cardiac issues. The data released by Health Policy Commission revealed that there was more than 3% rise in MRI services performed from 2012 to 2015” (“Medical Imaging Market”, 2019).

Automated pathology increases learning, skill and patiënt care

Automated Radiology-Pathology feedback tool: “The tool also allows radiologists to mark the results as concordant or discordant. Automated pathology feedback provides a valuable opportunity for radiologists across experience levels to learn, increase their skill, and improve patient care” (Doshi, 2019).

Increase in interventional radiology

“The global Interventional Radiology market is experiencing considerable growth due to factors like increasing preference for minimally invasive procedures and increasing technological advancements in interventional radiology devices” (Gerace, 2019).

Federated learning in the NHS

“Nvidia and King's College London have teamed up to build and train an AI platform to interpret radiological scans for hospitals across the UK. They employ federated learning in their NHS. Federated learning keeps data within its own, secure domain, while allowing algorithms to be developed at multiple sites using data located at hospitals around the UK” (Kennedy, 2019).

AI survey launched

“Radiologists and radiology residents from the U.S., the Netherlands, Germany, and the Czech Republic have teamed up to launch an online survey designed to gauge how members of the global radiology community view the use of artificial intelligence (AI) in their specialty” (Ridley, 2019).

FDA clearance for AI based diagnosis software

“Zebra Medical Vision, the deep learning imaging analytics company, today announces that it has received FDA 510(k) clearance for HealthPNX - an AI alert for pneumothorax (PNX), based on chest X-rays. This first of its kind FDA cleared solution can save physicians more than 80% of the time taken to reach the acute condition, compared to the traditional First In First Out (FIFO) methodology” (Shefayim,2019).

DI workstation market expects 3D, AI, Cloud and Expeditious networks

- Medical Imaging Workstation Landscape Witnesses Introduction of 3D technology
- AI, Cloud and Expeditious Networks to Ameliorate Future Medical Imaging Workstations
- Manufacturers Eyeing on Achieving a Good Price Point amid Ongoing Integration of High-Tech Features

(Mangesh, 2019)

Portable MRI

“Although MRI scanners are exceedingly effective at evaluating brain disease and injury, their large size, specialized sitting constraints, and high cost limit their impact by precluding them from most emergency medicine and acute care situations, including Intensive Care Units (ICUs), ambulances, and most hospital Emergency Departments. Researchers are validating the clinical potential of a portable MRI scanner through pilot testing of patient in the Emergency Department and Neurological Intensive Care Unit” (Wald, 2019).

FDA clearance for AI based triage software

“Israeli artificial intelligence (AI) software developer Aidoc has received clearance from the U.S. Food and Drug Administration (FDA) for AI software that can detect and triage pulmonary embolism on pulmonary CT angiograms. At ECR 2019, researchers from University Hospital Basel presented cases demonstrating the AI software's capacity to help manage pulmonary embolism without disrupting conventional workflows” (“Aidoc scores FDA clearance”, 2019).

More and improved procedures

“Increased numbers of diagnostic procedures carried out is expected to drive the market growth. Ability and achievement of personalized treatment, improved procedures and treatment of the patients are also expected to drive the market growth” (“Global AI in Medical”, 2019)

Unified workflow by integration

Carestream provides unified workflow in Brazil with a PACS, VNA, RIS, reporting workspace, universal viewer, patient portal and hospital administration software (“Brazil's Santa Casa”, 2019).

Teleradiology increasingly important
“The need of time-saving interpretation of radiographs with quality is high in developed economies where incidence rate of chronic diseases is rising at a rapid pace. In order to keep pace with the rising demand for radiological procedures and comprehensive interpretation, teleradiology is being preferred by health care providers across the globe. The global teleradiology services market was valued at US$ 4.6 Bn in 2017 and is anticipated to reach US$ 21.8 Bn by 2026. Rise in incidence of chronic conditions and adoption of teleradiology propel the global teleradiology services market” (“Teleradiology Services Market”, 2019).

Agfa sells part of HC business

The Belgian Agfa-Gevaert puts a part of its healthcare business for sale. The company announced this last Tuesday. For sale are the hospital IT and the integrated care, but also the imaging IT-activities as far as they are connected to the hospital IT. This impacts Germany, Austria, Switzerland, France and Brazil. For the other countries, the business stays in the hands of Agfa (“Agfa zet deel”, 2019).

Interviews

Sampling

For the second round of interviews a total of four radiologists were interviewed. An overview of the interviewees can be found in figure 40 below. All of the interviews were conducted at the locations that are shown on the map except for the interview with Lennart Blomqvist, with whom I had a telephone call.

Figure 40 – Map of interviewees

Insights of interviews

The interviews were transcribed and interesting insights were selected and coded. The codes are divided in either values, trends or future. Lennart Blomqvist preferred not to be recorded. Thus, the insights from that interview were noted down during the interview. Quotes from this interview are reconstructed carefully, the quotes from this interview were not stated literally in the conversation.

Interview Paul Algra

Board member & Head of Radiology Department, NWZ Hospital group

Quotes

"Maar wat je wel merkt bij de grote EPD leveranciers is dat zij uit die rigide ict wereld komen. Daarmee bedoel ik dat de producten die zij maken zijn helemaal niet gebaseerd op wat een gebruiker wilt en dat is wel irritant."

"Als we naar een ct scan van de longen kijken dan kijken we naar het hart, de longen, de lymfeklieren. We kijken naar alles. En dat kan Aidens niet, hij kan maar één ding, die vlekjes in de longen. En dat is maar een klein deel van ons werk"

"...gestructureerde data, waar zo'n computer heel veel mee kan. En dat geldt voor een aantal andere medische dingen niet zoals patiëntencontact, fysieke dingen zoals chirurgie, lichamelijk onderzoek."

Insights

Values
Contributing to the field
Ease of use is important but often overlooked
Efficiency and integration of systems is important

Trends
AI is too slow now because of getting used to
AI can only do a very specialized task
AI helping in workflow and pre-diagnose
Communication between specialists
Patients have a bigger role in their health
Patients doubting the diagnosis
Patients managing their own health
Increased care at home
Need for 2nd opinion in Eastern-Europe
Sharing of images for independence of geographical barriers

Future
Radiologists will trust AI in 1 year
Diagnosis by AI only will take time
Need for AI to help with increasing scans
AI will have a bigger impact than MRI
AI cannot help with patient contact and physical stuff
Controlling function of radiologist will increase
Contact and planning will stay the same
Amount of scans will increase

(Algra, personal communication, 20-5-2019)

(P.

Interview Maarten van de Weijer
Co-founder Koppl & Radiologist, NWZ Alkmaar

Quotes

"Je moet het ziekenhuis zien als een moederbord waar je allemaal modules in kan klikken.
Een technisch geneeskundige bepaalt dan wat voor een modules het beste zijn om aan te kopen:
wat voor een bedrijf, hoe gaan we dat integreren, hoe gaan we dat inrichten."

"Er komen meer vragen naar de aard van de diagnose.
Het wordt allemaal gewoon steeds complexer.
Die aanvragen worden steeds meer en meer."

Insights

Values

Trends
Sometimes there are holes in your work where nothing happens
AI gives false positives and takes longer
More scans and more complex scans
AI has too much false positives now
Need for correctly annotated data
Increase in scans

Future
AI for workflow optimization
AI gives protocol proposition
AI has added value because you miss less
AI can characterise tumors
AI stays a co-pilot
Contact with specialists will stay
Time gain will result in more time for complex cases
Reporting on scans will change the most
More controlling data role than reporting
Important to manage the data
We need a centralised system for AI implementation
Need for correct annotated data to implement AI
Need for an infrastructure to implement AI
We need to be the specialist of the AI
Contact with specialists stays the same, conversation will change
We need to be the specialists of AI
We become pilot and AI co-pilot
Need for correctly annotated data
GP does the diagnosis
Technical Medicine will have an increasing role

(M. van de Weijer, personal communication, 20-5-2019)

Interview Lennart Blomqvist

Co-founder Collective Minds Radiology, Professor at Karolinska Institute & Radiologist, Karolinska Hospital

Quotes

"The confidence has changed in the years.
In the old days, the confidence came from the senior radiologists.
But I think today to be confident you need to be fast and accurate
and know what you are doing and you need to know what not to do as well."

"On one hand, the clinical management of patient is getting more and more multidisciplinary.
But, on the other hand, the roles are getting much narrower in their part of this multidisciplinarity."

""I think the biggest change will be the realization of what machine cannot do.
I think that within 5 years we will see a lot of mistakes that AI makes.
When it is being implemented, there will be congresses full of challenges, mistakes and hesitations."

Insights

Values
Confidence is the most important in radiology

Trends
Shift from doctor as high power to fast and quantifiable care
Late digitization
HC field changes
Radiologist is connected to the world
Less interaction with equipment & more managing complex technical architectures
More multidisciplinarity
Subspecialization
New radiologists used to computers
Learning not only from mentor now but from the world
Change in awareness of what a machine can do
Connecting imaging to other information
Influencers are: traditional sources + Social media

Future
Realization of what machines cannot do
Private institutions will lead wave of tools
Regulations on interaction with equipment
Define interaction between industry and HC
Data from big companies get integrated

(L. Blomqvist, personal communication, 22-5-2019)

Interview Erik Ranschaert

Author of 'Artificial Intelligence in Medical Imaging', CMO Diagnose.me & Radiologist, Antoni van Leeuwenhoek & ETZ

Quotes

"Je rol, als behandelaar, als radioloog wordt daar duidelijk voor de patiënt en je kan ook effectief iets doen. een foto is vrij onpersoonlijk en als je de patiënt naast je ziet dan krijg je toch een soort persoonlijk getint iets. Ik zou dat niet graag missen in mijn werk."

"..een derde trend is nu de integratie van virutal imaging, waarbij dus door radiologie of andere beelden geintegreerd worden met therapieen van chirurgen."

"Je hebt nu nog teveel separate systemen in het ziekenhuis. Archief van de ene specialist, en de andere specialist, metingen van de een en van de ander. Al die data moeten bij elkaar geintegreerd worden. En dat is de toekomst, dat we die data integreren."

Insights

Values
Helping the referring clinicist
Helping the patient
Communication with patient and referring clinicist
Personal contact with patient
Love for technology
Radiologist is a distributor

Trends
Radiologist loses ground to IT
Data becomes more complex
Personalized medicine
AI trend
Integration of Imaging with other tasks
Growing need for imaging
Clustering of hospitals
Clustering because of skill of doctors

Future
Need to keep up
Broad data of patient
Decide in treatment
Data driven decision making
Use imaging to help with surgery
AI for improved workflow
Bad side of AI
Only elite can use AI
Workflow AI will be integrated by the scanner providers
PACS will disappear for VNA in 10 years
Centralized archive for whole country
PPP standardises care and will disrupt European market
Radiologists will become data analyst
Interventional radiology increases
Role of radiologist in decision making will increase
More contact with specialists and with patient
Analysis by helpers and software, Radiologist will give holistic perspective
Quantitative data instead of opinion radiologist

(E. Ranschaert, personal communication, 23-5-2019)

Future visioning

This cycle of the vision contains more interviews and a wave of recent news and papers. The insights from the trend research and interviews were clustered in two phases. In the first phase two students helped with the clustering. The second phase was done by me individually.

The clustering process will be explained below. The purple notes are values mentioned by the radiologists, the yellow notes are trends, the blue notes are future visions of the radiologists and the pink notes are clusters.

Phase 1

The students have knowledge of clustering, but they are not up to date regarding the topic of Diagnostic Imaging. This means that their input is valuable in the sense that they have no bias towards the topic. However, the connections they make may not be as relevant. The clustering process was done freely. The students were instructed beforehand about the goal of the clustering, the different colours and an explanation of several terms in radiology. These were printed on a sheet of paper for the students to look at if something was unclear. This sheet can be found in appendix B. The first phase of the clustering can be seen in figure 41 and 42.

Figure 41 & 42 – Clustering process second cycle, first phase

The students and I chose to take the values of the radiologists and connect trends to this. After this, the future vision notes were put behind relevant trends/values. This created a linear 'cause-effect' chain where the values are translated into a vision through current developments. This method worked fairly well and the structure was kept for the second phase. However, there are a lot of connected 'chains' and the connections between them are not represented to their full potential.

Phase 2

In the second phase I used the 'template' of the first clustering and moved some of the trends and visions to other clusters. In order to make connections to other chains the decision was made to make the clustering circular. In this way every chain has a connection with two adjacent chains and notes could be placed in between them. The second phase of the clustering can be seen in images 43 to 46.

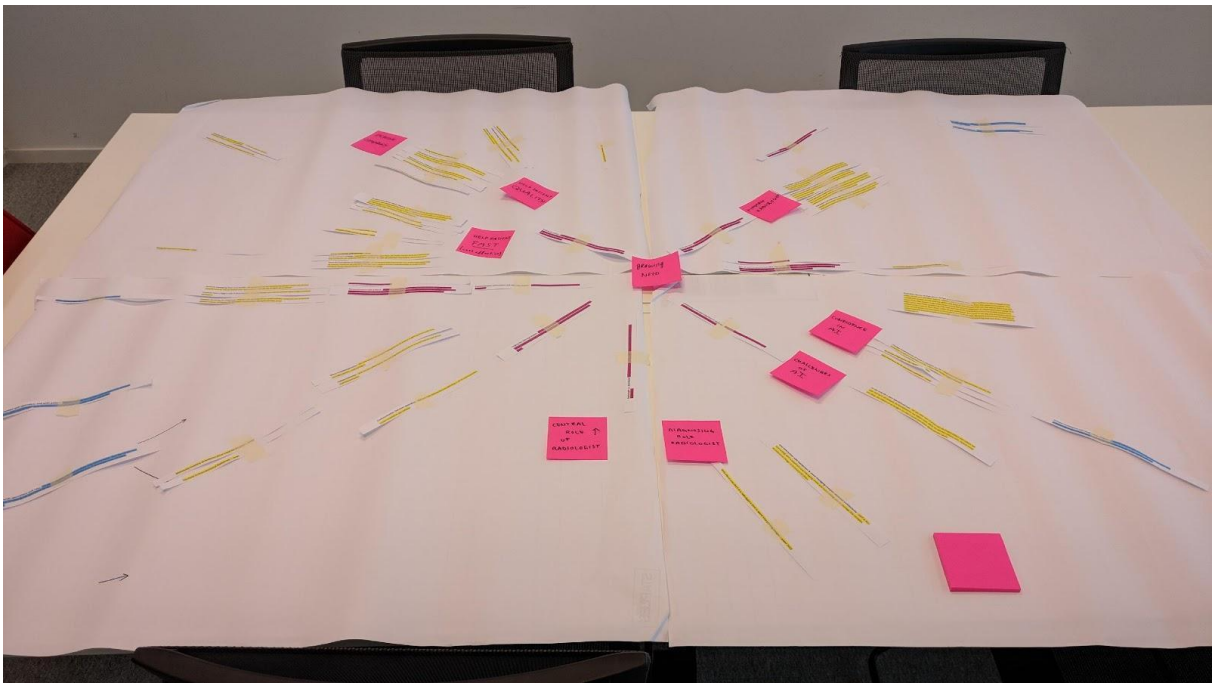


Figure 43 to 46– Clustering process second cycle, second phase

Future vision directions can be derived from the final clusters. These are represented in figure 47.

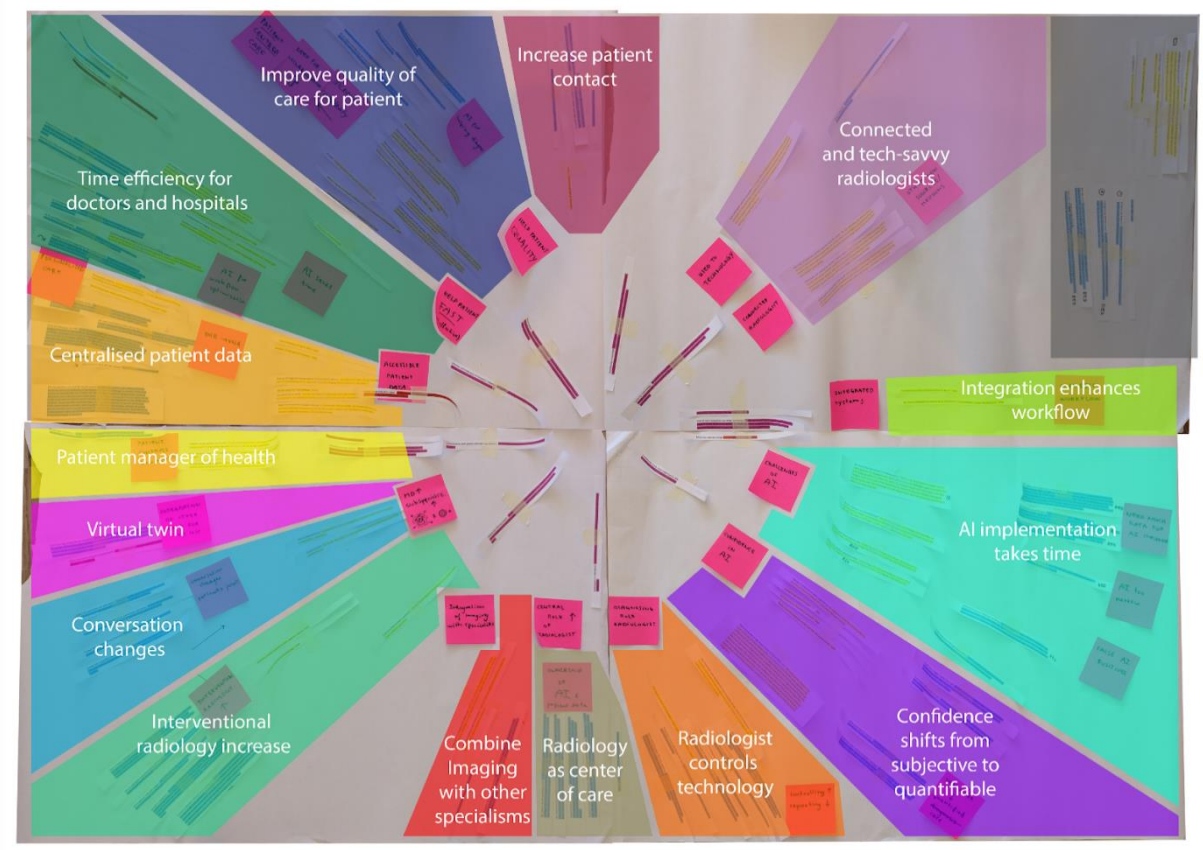


Figure 47 – Highlighted future directions

This cycle confirms the earlier vision for the main part, the need for diagnostic imaging will grow significantly. This is visualized in figure 48. To be able to keep up with the demand, there is need for technology that can reduce the time spent by helping with triage, prioritization and diagnosis.

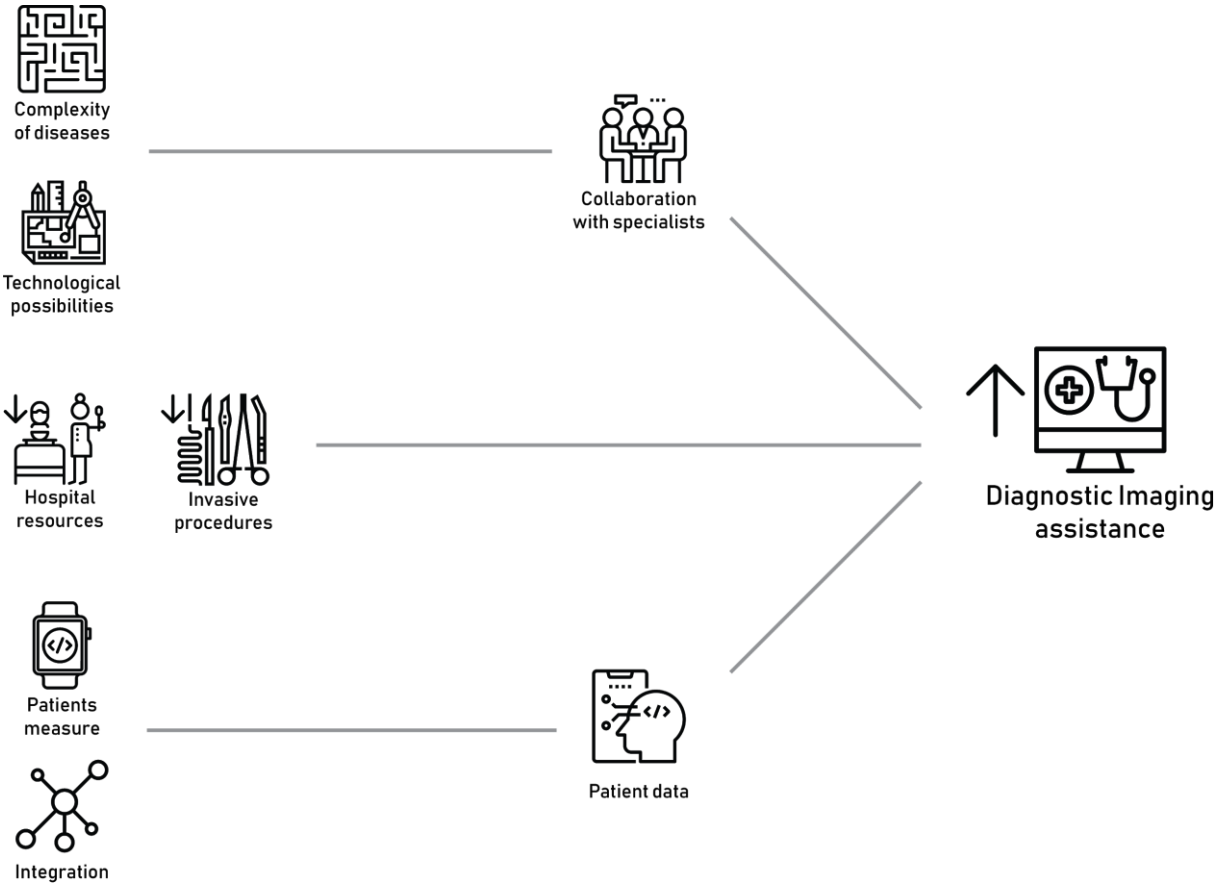


Figure 48 - Growth in medical imaging

Whatever technology is going to assist in the work of radiologists, the radiologists will be the owner of this technology. The technology will not have the deciding role in a diagnosis, at least not in the foreseeable future. What technology is used, how it is used and what the limitations are of the different technologies will be the responsibility of the radiologist.

Integration is the key word of this future vision. The role of radiology is integrating into other parts of the care. At the same time, data and systems are integrating together for a more efficient and seamless workflow.

"...the second wave of the digitalisation"

– Lennart Blomqvist

Accessible patient data is becoming regular practice, the system is moving towards a VNA solution where all healthcare providers can access a single database where data of a patient is stored. This will drastically increase the amount of available data and thus there will be potential to alleviate the care to a higher level. This demands a more multidisciplinary role of the radiologist and the ability to overview the situation.

This multidisciplinarity will change the conversation between the radiologist and other care professionals. There may be more people in the conversation with additional subspecialties. Not only the conversation will change, the working area will change as well; as interventional radiology will increase, so will the influence of radiologists in other areas.

An important paradigm shift will happen and is in fact already happening: Radiology must be interpreted as 'explaining the inside' and 'seeing the invisible' and not as diagnosis based on an order. Imaging of patients will be used as assistance to the work of other care professionals.

In conclusion, the second cycle of the future vision: The work of radiologists is to 'explain the inside' as it is integrated into the work of other medical specialists. Accompanied by this role change, patiënt data, care software systems and hospitals are integrated as well.

Where radiology used to be a link in the chain of 'providing care', it is becoming the ring that holds multiple links together.

A visual representation is given in figure 49, the role as it is now (left) and the role in the future (right).

Figure 49 - Change in the role of the radiologist

Learnings

- When talking about the future vision, send the interviewees material to think about before interviewing them.

E: Trend patterns with insights

Tech-Savvy radiologists

Because of a rapid increase in imaging techniques, visualization support and algorithms, the radiologist changes into an imaging shepherd managing a flock of available techniques. Being aware of these new possibilities and having the knowledge to apply them becomes a key role in their job. The actual work that radiologists carry out is becoming more and more connected to technology.

Radiologists must consider complex cases and manage AI systems

Elastography expects strong growth

AR assisted diagnosis of livers

Holographic (AR) surgery assistance FDA cleared

Automated breast ultrasound 3D systems on the rise

Radiologist controls the data - Ik denk dat we ervoor moeten zorgen dat we de data blijven controleren en dat het niet een soort race wordt met de orthopeden die 3d modellen willen maken met de data.

Medical and technical interest - Ik denk dat het meest ideale is als iemand een been in de techniek en een been in het medische, dat dat het meest ideale is.

Advising on imaging technique - we don't work in isolation anymore, we have far more engagement with commissions. And we do that in two ways: one is that we give advice on what the proper imaging technique is.

Manager of the algorithms and their input - hoe is een algoritme opgebouwd, welke data liggen eraan ten grondslag, waar zijn die data verzameld, welke periode, welke scanners en hoe beinvloed dat je resultaten

We have to manage the technologies - Als de computer dat doet dan kan de longarts ook denken van ja we bypassen de radioloog, maar de longarts heeft niet zozeer kennis over hoe zo'n programma is opgebouwd, wat voor een fouten daar in kunnen sluipen, dus dat moeten we voorkomen.

Knowledge of the imaging techniques - Achtergronkennis over de beeldvormende technieken, dus protocol, samenwerking met de laboranten, ja de beperkingen van een onderzoek zijn ook heel belangrijk.

Determining algorithms - En misschien wat voor een algoritmes er moeten komen. Supervisie eigenlijk van dat proces.

Radiology department has a data scientist - Zoals de ideale radiologie afdeling van de toekomst waar elke afdeling een data scientist heeft.

Being the key between different systems and data - En een sleutel spelen in die meer en meer gecompliceerde combinatie van verschillende systemen met verschillende metadata.

Subspecialization, narrowing expertise - Men wordt steeds meer gespecialiseerd (de radioloog). Er zijn steeds complexere beeldvormingen mogelijk, functionele componenten. Er zijn allerlei add-on technieken die worden ontwikkeld waar wij ons in moeten verdiepen dus je kennis wordt steeds smaller omdat er steeds meer kan.

Medical Imaging Workstation Landscape Witnesses Introduction of 3D technology – news

Portable MRI – news

Love for technology - De tools die we gebruiken worden geavanceerder en interessanter. Die nauwe binding aan techniek vind ik opzich wel heel bijzonder voor radiologie, en het maakt het wel aantrekkelijk.

Radiologists will become data analyst - Ik denk dat we meer data analist moeten worden. We gaan meer de data die we aangeleverd krijgen moeten gebruiken. We gaan onze manier van verslagleggen totaal moeten veranderen.

More controlling data role than reporting - Ik denk dat de werkwijze die we hebben gaat veranderen. Dus dat we gaan van kijken naar de beelden naar een meer controlerende en data functie gaan. Dus ik denk dat de rol van de radioloog gaat veranderen.

Important to manage the data - Wij beheren de data van alle scans die gedaan worden. Ook voor het ontwikkelen van AI heb je die data gewoon nodig voor het annoteren, valideren en andere nieuwe ontwikkelingen. Dus ik denk dat het heel belangrijk is voor ons om die data te blijven beheren.

We need to be the specialist of the AI - ik denk dat wij nog steeds opperspecialist moeten zijn op het gebied van AI dus je moet een overlegsituatie creeeren waar de eindspecialist die scan ziet, die al gezien is door de AI, maar die specialist heeft daar dan vragen over. Ik denk wel dat we een slag moeten winnen, en dat is dat we AI uitdragen vanuit ons vakgebied. Dan heb je toegevoegde waarde en bestaansrecht. En je moet er meer van weten dan de rest, van de achterliggende zaken enzo.

We become pilot and AI co-pilot - Ik denk dat we in dat opzicht een soort data managers worden. Dus ik denk dat onze rol verandert maar niet verdwijnt. Bijvoorbeeld de vergelijking piloot en automatische piloot. Er zijn nog steeds piloten aan boord. Terwijl het vliegtuig vliegt zelf, zie de overeenkomst.

New radiologists used to computers - it's a quite different generation compared to twenty or thirty years back. So they come from a background where internet and computers are part of the daily life and even tablets are part of the life. So if the residences of radiology are already quite familiar with working in this way from day one..

Controlling function of radiologist will increase - Het percentage AI zal toe gaan nemen. Mijn controlerende functie zal steeds meer toe gaan nemen (wat komt er uit de AI, eens of niet eens).

Quantification of care

With the rise of new technologies that assist healthcare professionals, the amount of quantified data increases in parallel. The confidence in healthcare is changing from a subjective verdict from human professionals to a quantified and objective verdict by computers. This includes AI, Radiomics and IT trends.

Deep learning and radiomics in precision medicine

Radiologists expect AI to reduce imaging-related medical errors

Radiologists expect AI to cut image-interpretations times

Radiologists expect AI to increase time spent with patients

Biggest AI impacts: Screening, Triage and Prioritization - expert

FDA clearance for AI detection software – news

AI based triage gains FDA approval – news

AI app-store gives access to range of AI models

Reproduction of radiomics features through neural network

AI helps in mammography triage

Data driven decision making - informatie die we daarvoor gebruiken moeten we zo goed mogelijk quantificeren. Actionable maken. Anders is het natte vinger werk, gebaseerd op een subjectief iets.

Connecting imaging to other information - Together with how digital information from images can be connected to other information (radiomics).

AI trend - En dan natuurlijk AI development is trend nummer twee.

AI for improved workflow - Wat de workflow betreft daar heb ik het dan over optimaliseren van scheduling van patienten, reduceren van scantijden, straling, meer info uit de beelden halen, de communicatie faciliteren

Radiologist loses ground to IT - De radioloog heeft naar mijn aanvoelen de touwtjes daar losgelaten, wat ik jammer vind. Wat ik ook zie is bijvoorbeeld assistenten, jonge radiologen, die komen op een afdeling en zien al die schermen staan. Voor hun is het allemaal logisch en ze denken er niet meer over na van hoe werkt het, hoe zit het in elkaar.

Quantitative data instead of opinion radiologist - Dat denk ik wel: dat we veel meer informatie aangeboden krijgen, daarom zeg ik data analisten. Het is een verschuiving van morfologie naar functioneel en kwantitatieve data. Dus niet alleen de plaatjes beschrijven, dat is passe.

AI for workflow optimization - Ik denk dat een belangrijk deel van AI workflow optimalisatie wordt. Met contrasten weergeving, spoedpatiënten tussendoor, inplannen van patiënten.

AI has added value because you miss less - AI heeft een grote toegevoegde waarde want je mist minder. Dat is een grote toegevoegde waarde: het niet missen van een afwijking.

AI can characterise tumors - Daarnaast denk ik dat het een grote toegevoegde waarde heeft voor de karakterisatie van tumoren.

Reporting on scans will change the most - Het grootste verschil zal gaan liggen in het verslagwerk, de sheer load van wat we doen

Technical Medicine will have an increasing role - In elk ziekenhuis denk ik dat er een grote rol gaat zijn voor de technisch geneeskundige, iemand die alles begrijpt van de apparaten en de AI in een ziekenhuis. Je moet het ziekenhuis zien als een moederbord waar je allemaal modules in kan klikken. Een technisch geneeskundige bepaalt dan wat voor een modules het beste zijn om aan te kopen: wat voor een bedrijf, hoe gaan we dat integreren, hoe gaan we dat inrichten.

Confidence is the most important in radiology - Confidence in different levels. It is like a stock market, everything is built on confidence.

Shift from doctor as high power to fast and quantifiable care - The confidence has changed in the years. In the very old days, before I started, the confidence came from the senior radiologists. The confidence of that person and the ability and skills of that person that was the whole thing that you could trust. The person might have been wrong like an overdiagnosis, or might have seen things that didn't exist. But if the confidence that that was the truth, that led to a treatment that enabled the patient to be healthy. But I think today to get confidence, you need to be fast and accurate and know what you are doing and you need to know what not to do as well. Because everything has become so subspecialized and technically increasingly complex that from everything that you make you need to categorize it.

Change in awareness of what a machine can do - Awareness of what the machine can do, the potential of what a machine can do. I think that is the biggest change.

Radiologists get checking role - En dat we steeds meer een controlerende functie gaan hebben.

AI helping in workflow and pre-diagnose - in Leiden bijvoorbeeld, daar gaat alles eerst naar de AI, dan wordt er een opdeling gemaakt tussen spoed en geen spoed en er wordt een eerste indicatie van de diagnose gegeven. Leiden UMC zijn daar in September mee begonnen en ik verwacht andere UMCs ook. Dus de triage, de ordening en de eerste diagnose.

Artificial Intelligence will replace repetitive tasks (radiologist job will change: less screening & time for other activities, impact after 2025)

Artificial Intelligence will begin decision making (radiologist job will change: less screening & less diagnosing time & more time for other activities, impact after 2026)

Biggest impacts of AI: Screening, Triage and Prioritization

Healthcare becoming remote

A large part of the care for patients can be done remotely, away from the hospital. This includes teleradiology, radiologists working from home. Additionally, prevention and first line care are preferred over hospital visits.

Teleradiology market expected to grow in Europe

A big investment in teleradiology for Europe

Teleradiology growth driven by eHealth, integration of systems, long-term diseases, government funding

Patients going to outpatient imaging centres (US)

Breast imaging sites make the mammogram experience more pleasant (US)

Contact with GP and remote consultation - En het feit dat de huisarts bijvoorbeeld foto's kan laten zien met: hier ziet de radioloog de afwijking en dan kunnen we bij wijze van facetime nog extra uitleg geven.

Breaking the chain between radiologist and workspace - So one of the real changes is more home reporting, more off-side reporting. Break the chain between the radiologist and the workspace and potentially breaking the chain between a radiologist and a single institution

Need for screens designed for home use - we need to have screens that fit this role. We need to have screens that cope with the fact that we are not in that very closed artificial environment and they need to cope with home environments.

Possibillity to do MDO remotely - Als je vraagtekens hebt bij twintig patiënten dan kun je er doorheen in een uur of anderhalf uur. Dan kun je met één consensus de kamer uit lopen. Maar heb je die mogelijkheid niet, om een overleg te doen. Dan is het misschien mogelijk om het met nieuwe technologieën te doen. Zoals iets als skype, of een chat.

More working from home, away from the patient - Want meer mensen willen van huis gaan werken en niet meer op het ziekenhuis zijn. En er is een trend dat mensen meer en meer op de beelden willen focussen. En niet zoveel meer op de ziekenhuizen te zijn. Er is een trend waar de radioloog eigenlijk verder weg van de patiënt gaat dan nu.

Screening done through teleradiology or AI - En ik denk waar wij beelden zitten te bekijken, dat kan eigenlijk gedaan worden door AI of teleradiologie systeem. Om de patiënten en de diagnosen en de processen zo efficiënt mogelijk in te zetten is niet om die eenvoudige beelden te analyseren. Dat kan eigenlijk geanalyseerd worden op een makkelijke manier.

Teleradiology because of the location - Als je in Nederland zit dan heb je zo 4 of 5 UZs die dat op kunnen lossen. Maar in sommige regio's is het 5 uur om naar een ziekenhuis te komen. En daar zijn de mogelijkheden heel anders.

MDOs done remotely - Ik zie dat de fysieke ontmoeting met een videoconference meer en meer een mandatory procedure. Dus ik denk dat er oplossingen komen met hetzelfde resultaat zonder de fysieke ontmoeting. Dus misschien is dat een video ontmoeting met alle specialisten achter hun eigen computer.

Rising market for Teleradiology – news

GP does the diagnosis - *een huisarts die onderzoeken kan doen?* Dat denk ik wel, dat de radioloog er op die manier niet meer aan te pas komt.

Need for 2nd opinion in Eastern-Europe - In Nederland is dit wat minder van toepassing omdat hier de meeste medische specialisten goed zijn. Maar andere landen zoals Slowakije en andere Oost-Europese landen bijvoorbeeld is dit ontzettend nuttig.

Increased care at home - mensen met chemotherapie thuis, dat hoeft niet per se in een ziekenhuis. Het monitoren van diabetes hetzelfde verhaal. Dus dat zijn allemaal interessante ontwikkelingen.

Sharing of images for independance of geographical barriers - Hier speelt het delen van die beelden ook een ontzettend grote rol natuurlijk omdat dan de geografische barrière er niet meer is.

Tele-Health, remote medicine, mobile health

PACs stations at home of some radiologists, this will increase (impact now & will grow)

Connectivity will grow: virtual, digital and physical (Easier contact with care providers & between care providers & navigation to hospitals, impact now, will grow)

Empathic radiologists

While technology and data play an ever-increasing role in healthcare, there are some tasks that cannot be automated. These tasks involve empathy and social and physical contact with patients or other specialists. This human side of care is important to patients and care-professionals.

More direct contact with patient - En dat die patiënten steeds meer aan de radioloog willen vragen en niet aan de andere dokter of huisarts. In dordrecht bijvoorbeeld doen de radiologen zelf de mammopoli, die hebben zelf contact met de patiënten.

Interventional radiologist has direct contact with patient - de interventionele radiologen die praten zelf nog met een patiënt op het moment dat ze een behandeling uitvoeren.

More time for empathy and complex cases - So we can concentrate more on the aspects that require human interaction: the empathy and complex interpretation side of things.

Contact about the content with results - Ik vind persoonlijk menselijk contact over de inhoud erg leuk, maar het moet wel resultaat hebben. Vaak heb ik het idee dat het nog wel eens inefficient gaat.

More direct contact - Maar in de laatste RSNA, of twee jaar geleden, was het meer en meer de discussie dat wij eigenlijk meer uit de zwarte kamer moeten komen om direct contact te hebben.

More time for communication with colleague and patient - als we meer hulp krijgen van AI enzo om die beelden te bekijken, dan krijgen we meer tijd om betrokken te zijn bij het proces tussen de orthopeed of de oncoloog en de patiënt

Fill non-automatable role like patient contact - eigenlijk proberen we tijd te krijgen voor dingen waar je minder makkelijk weggestuurd kan worden of overgenomen door AI. Waar eigenlijk ons contact met patiënten noodzakelijk is, en andere dingen waar we niet vervangen kunnen worden.

Patient contact, MDOs and collecting information become important - de waardering van de werkgever om beelden te bekijken zal minder en minder worden in tien tot twintig jaar. En andere dingen, wat minder gebruikelijk is zoals patiëntencontact, MDO's sturen en informatie verzamelen.

Consultation expected to increase

Rewarding to deal with patients - expert

Improving of patient interaction – news

Communication with patient and referring clinicist - communicatie met de aanvragende arts en met de patiënt.

Personal contact with patient - Je rol, als behandelaar, als radioloog wordt daar duidelijk voor de patiënt en je kan ook effectief iets doen. een foto is vrij onpersoonlijk en als je de patiënt naast je ziet dan krijg je toch een soort persoonlijk getint iets. Ik zou dat niet graag missen in mijn werk.

More contact with specialists and with patient - meer overleg met andere specialisten? Ja, dat ook. Misschien zelfs rechtstreeks met de patient. Dat zal zeker ook wel ergens toenemen

AI stays a co-pilot - AI kan naar tienduizenden dingen kijken, het kan je de goede richting op sturen. Maar het blijft altijd een sturing.

AI cannot help with patient contact and physical stuff - gestructureerde data, waar zo'n computer heel veel mee kan. En dat geldt voor een aantal andere medische dingen niet zoals patiëntencontact, fysieke dingen zoals chirurgie, lichamelijk onderzoek.

Successful patient outcomes have to do with the psyche of how patients approach, feel and prepare themselves for the encounter with healthcare

It is rewarding for a radiologist to deal with patients

Contact with the patient became and will become more and more relevant

Developments should be used for better diagnoses, contact with patient and contact with referrers

Self-direction of health by patients

Patients make their own decisions regarding their health. As opposed to the past where doctors had all of the authority and credibility, the patients are now able to form their own (expert) opinion. They can ask for specific doctors and they can request a second opinion online. Additionally, the patients need answers to their specific questions about the diagnosis or treatment.

User of imaging is not only radiologist anymore

Easier communication with patient - Dus ik denk dat de patient eerder zal vragen van wat vind de radioloog ervan, ik denk dat dat makkelijker wordt. Ik denk dat we beter gaan communiceren en dat moet eigenlijk wel.

Patient joins MDO - In de US wordt soms de patient bij de MDO gehaald, die wordt dan ingebeld en die kijken mee over wat er besproken wordt.

Patients voice stays important - Maar wil die persoon het dan wel. Je hebt ook wel eens mensen die een behandeling weigeren. En dan kan je algoritme nog zo zeggen dat iets moet. Maar er zit altijd een mensenkant aan, en die is niet zomaar te ontnemen en te vervangem door technologie

Second opinion websites for patients - er bedrijven ontstaan en platforms ontstaan voor second opinions. Dat de patient denkt van kom maar hier met die scan, ik vertrouw het niet. En je betaalt 10 euro om het onine te laten beoordelen en dan kom je terug naar de arts en het algoritme zegt dit. En wat dan?

Marketing and profiling of hospitals is important - Het wordt ook steeds belangrijker om jezelf te profileren en actief te blijven innoveren. Dus ook de cultiuur verandert. Marketing is ook steeds belangrijker voor een ziekenhuis en daardoor is innovatie ook steeds belangrijker.

People want to see their images - *mensen zijn steeds benieuwder naar hun eigen gezondheid en ze nemen steeds meer de regie in eigen handen...* Zeker, daarom willen ze ook de beelden inzien enzo.

Contact and visibility to patient - Wat belangrijk is voor ons is contact met de patient, zichtbaarheid naar de patient dus ik zou me kunnen voorstellen dat er een scenario is waarbij we ook spreekuren hebben met vragen van patienten of uitleg over de uitslag.

Consultation expected to increase

Improving of patient interaction – news

Patients have a bigger role in their health - is dat patiënten een steeds grotere stem krijgen/hebben gekregen.

Patients doubting the diagnosis - Mensen die de diagnose in twijfel trekken. Diagnose.me → second opinion online, zelf keuze uit specialist (nationaliteit, deelspecialisatie, prijs)

Patients managing their own health - De ontwikkeling van mensen die dingen meten bij zichzelf (mobile health). Dat je steeds meer een regisseur wordt van je eigen gezondheid.

Accountability and Transparency will grow (Need for quality control of every element in the hospital, impact now & will grow)

Patients have become more assertive and knowledgeable (impact now & will grow)

Parallelization of imaging in healthcare

The usage of DI in care is increasing. This happens not only in depth (specialization), but also in breadth (parallelization). DI is not only used after referral, instead it is used in prevention, early detection and treatment among others (e.g. Radiography, Interventional radiology, surgery, first aid). DI is used as guidance and becomes integrated into various care processes, other than diagnosis.

Radiology has touchpoints with every other specialty

Chronic diseases drive interventional radiology market

Growing market for interventional radiology

Growing market for radiography-fluoroscopy

Radiologists at the first aid - En een ander ding is meer op de eerste hulp waarvan ik denk dat radiologen een prominentere rol kunnen hebben.

Faster and more accurate care when radiologists are at first aid - Vroeger zaten we helemaal niet op de eerste hulp. Als er radiologen bij de eerste hulp bij zijn dan worden patienten eerder het goede pad in geleid en dit zorgt op zijn beurt weer voor minder heropnames.

Surgery assisted by radiology - Waar vroeger chirurgen sowieso opereerden zonder enige beeldvorming. Dat daar bij alle operaties, of ja alle… men doet geen chemo meer zonder dat er beeldvorming aan te pas is gekomen.

Process of treatment assisted by radiology - dat het proces in de behandeling veel meer in kaart gebracht gaat worden. Of de chemotherapie aanslaat, ontwikkelingen bij prostaatkanker, beeldvorming waarbij je kan zien of het bij de kankercellen aankomt en hoe actief die zijn.

Treatment and diagnosis are overlapping - But the other aspect is that even treatment or diagnosis is now more closely aligned when things are put more into context and having a close dialogue. So treatment and diagnosis are overlapping nowadays.

Fusion with nuclear medicine - We zijn natuurlijk recent gefuseerd als opleiding met de nucleaire, dat is ook een ontwikkeling. Dus we worden ook straks gezamelijk een combinatie van beiden, een specialist medische beeldvorming.

Less invasive procedures - Oncologie is groot, ook van bestraling en andere dingen. Wij hebben ook meer en meer van chirurgie. De mate van chirurgie wil je natuurlijk minder en minder doen. Daarom is het gedaan met een interventionele methode of microchirurgie. Dat soort dingen worden meer en meer ondersteund door beeldmateriaal.

Imaging important for others not only in diagnosis - ik denk dat beelden meer en meer belangrijk gaan zijn voor andere specialisten in hun werk. Niet alleen voor diagnoses, maar ook voor ondersteuning in andere dingen die ze doen.

Minimally invasive procedures drive need for displays – news

Increase in Interventional Radiology – news

Decide in treatment - Niet alleen de diagnose maar de behandeling meesturen. Want met onze beeldvorming kunnen we zien of een bepaalde therapie aanslaat. Als wordt gezien dat iets niet aanslaat dan kan er een nodeloos dure behandeling worden stopgezet en misschien een andere effectievere behandeling gekozen worden. Dus wij gaan echt meer actief beleid bepalen van een patient.

Integration of Imaging with other tasks - een derde trend is nu de integratie van virutal imaging, waarbij dus door radiologie of andere beelden geintegreerd worden met therapieen van chirurgen.

Use imaging to help with surgery - we moeten die beelden meer en meer gebruiken om dingen te doen in het lichaam. I.p.v. blind gaan we dan beeldgeleid dingen doen.

Interventional radiology increases - Sommige dingen gaan blijven zoals de interventie. En die zullen ook toenemen zoals de beeldgeleide interventie. Als je manieren vind om patienten op minder invasieve wijzen te behandelen dan is dat een goede zaak. En hoe meer je dat kan doen, hoe beter. Dus daar gaat ook een verschuiving plaatsvinden.

Minimally invasive procedures drive need for displays

Complexity of the scans increases, radiologists involved in treatment more and more (impact now & will grow)

Centralized patient data in the cloud

Patient data is getting more accessible as databases get integrated through the use of EMRs. This centralization ultimately leads to a solution referred to as a VNA (Vendor Neutral Archive). This database is then accessible to patients and care-professionals. The more data this database has, the better and faster the care and the healthier the patient. Computing of this data can be done on the same premise as well.

NHS' patient data sparks interest of pharma companies and Alphabet

Quality assurance through reward of patient data (US)

Neutral platform - Vandaar moeten we een neutraal platform hebben en je kan van alle zenders apps er in pluggen, dan kan het systeem zich door ontwikkelen. Ik mis grotendeels de regie een beetje, wie gaat nou waar voor zorgen in deze toekomst?

Global archive of all medical data - What you need is some kind of globalized archive where you can extract data from, doesn't matter where it is because you can access it anywhere, and the means to access the imaging and manipulate the imaging in a diagnostic fashion.

Cloud computing in the VNA - People are increasingly developing along web-based products so effectively all you need is a decent screen and access to the internet and you are away. So then you would have cloud computing, maybe even in the same places as the archives would be.

Adoption of EHR systems increases – news

Universalization of Patient Data – news

Broad data of patient - ik denk dat er wel een moment gaat komen dat er veel bredere data beschikbaar is van die patient. Misschien zelfs de soort virtuele kopie, de virtual twin van die patient.

Centralized archive for whole country - het meest ideale is om ervoor te zorgen dat er een beveiligd systeem komt wat beschikbaar is in t hele land. En dan heb ik het over een soort centraal archief. Overheidsgereguleerd zou kunnen, maar blockchain zou ook een rol kunnen spelen. Dat de patient de touwtjes in handen heeft.

Cloud services grow like computing, storage, etc. (Reduction of local computing & PACs, impact now & will grow)

Enterprise Imaging is Having a Greater Influence on VNA

Adoption of EHR systems

Universalization of Patient Data

Electronic Health Records (available but still not enough supported)

Universally computable EHR

Big Data Utilization in care of patients and HC systems management

Healthcare market is burning up

Hospitals have no resources - Ziekenhuizen hebben geen geld meer, dat komt allemaal voort uit de prijzen die naar beneden gedreven worden. Je hebt helemaal geen geld meer als ziekenhuis.

Great economic consequences of burnout under physicians

Need for more doctors but no time to train them - we got this rather strange paradigm that we need more radiologists, we need more people to interpret imaging but we don't have time to train them properly. So if we could offset some of the more straightforward tasks we create more time for the teaching as well.

Hospitals have less and less money (Shift to OPEX models & tenders will increase, impact now & will grow)

Increasing OPEX model: renting and leasing equipment (change in interaction with channels, impact now & will grow)

Slowdown in job creation (shortage of radiologists & need for automation grows, impact over next years)

Shortage of health professionals (shortage of radiologists & need for automation grows, impact within 5 years)

Change to value-based healthcare

Amount of hospitals, beds, length of stay, number of professionals decreases (impact now & will grow)

Low fertility rates (Lower number of specialists, impact somewhere after 10 years)

Aging population (Increased need for healthcare and screening, impact now, will grow)

Integration of hospitals and systems

For hospital systems (PACs, RIS, EMR) to be as efficient as possible, they have to work flawlessly together. Providers are increasingly delivering complete systems for a better workflow. Additionally, hospitals are clustering together to become subspecialized. One data format is needed to support the complete integration.

Fujifilm develops integrated PACS

Harmony between suppliers and users - I think I would love to see better harmony between suppliers and users so we can co-develop things.

Bad engagement with PACs and EMR companies - I think there is far better engagement from radiologists with PAC companies and with EMR companies in the US than there is here. We still have these walls and barriers.

HIVE technology for MDOs - En dan bestaat er zo'n soort technologie zoals het gebeurt in een beehive zodat dan mensen trekken aan verschillende kanten van de conclusie en dan kun je als één speler of meer spelers AI hebben en dan kan een groep naar een conclusie komen, waar je met één of twee mensen nooit was gekomen.

Determine the format and not the product in integrating systems and data - Ik denk dat wat belangrijk is is dat je niet de producten samen koppelt maar dat je de metadata en principes samen koppelt. Dat formaat van communicatie is dus besloten in plaats van te zeggen dat iedereen dit of dat merk moet hebben.

I propose a no PACS trend – expert

AI, Cloud and Expeditious Networks to Ameliorate Future Medical Imaging Workstations – news

Carestream provides unified workflow in Brazil – news

Clustering of hospitals - Nu word er ingezet op die ziekenhuisnetwerken per regio. En die zijn dan verantwoordelijk om de patientenpopulatie te helpen. Meestal zit er een academisch centrum in. Maar dat is zeker een trend die nu ingezet is

Clustering because of skill of doctors - De kundigheid van het team ter plaatse. Chirurgen, Oncologen, het personeel dat daarf werkt, de technieken die worden gebruikt. Die worden gestandaardiseerd zodat men meer ervaring krijgt in dat specifieke onderdeel.

PPP standardises care and will disrupt European market - Je hebt nieuwe spelers zoals Affidea. Dat is een bedrijf dat actief is in 16 landen, zij specialiseren zich vooral in radiologische beelden, diagnostiek, ook met bloedonderzoek. En zij maken die PPPs. Ze hebben beeldvormingsapparatuur zo veel als Nederland, dus ze zijn een enorm sterke speler op de markt. En het voordeel van zo'n speler: Ze zijn nu heel actief aan het inzetten op het standaardiseren van de werkzaamheden in alle landen waar ze actief zijn. Overal dezelfde kwaliteitscriteria, overal dezelfde manieren van werken, protocollen, overal communicatie onderling, opleiding, gecoordineerd gebruik van tools, software. Ze hebben data uit 16 landen die ze kunnen gebruiken. Die gaan echt de markt disrumperen. Zij kunnen van al die data gebruik maken om software te ontwikkelen en algoritmes mee maken. Die gaan een enorme sterke positie krijgen in de markt

We need a centralised system for AI implementation - Voordat we AI kunnen gaan gebruiken dan moeten we nog een infrastructuur bouwen waar je bang van wordt. Omdat nu alle PACS systemen van de ziekenhuizen nu nog los zijn, die moeten dan op een cloud centraal gedraaid worden.

Ease of use is important but often overlooked - Maar wat je wel merkt bij de grote EPD leveranciers is dat zij uit die rigide ict wereld komen. Daarmee bedoel ik dat de producten die zij maken zijn helemaal niet gebaseerd op wat een gebruiker wilt en dat is wel irritant.

Efficiency and integration of systems is important - Efficientie van de systemen kan beter, beter geintegreerd met elkaar en de wachttijden omlaag

Enterprise Imaging Adoption for Radiology is Set to Continue

Enterprise Imaging is Having a Greater Influence on VNA

Opportunities for Standalone Universal Viewing Will Diminish

Clustering of hospitals in Belgium and Europe (impact now & will grow)

Complex diseases cause collaboration

An increase in (sub)specialization and the increasing amount of complex diseases (various causes that are not yet fully mapped) causes care specialists to collaborate more. This expresses itself in an increase in number of multidisciplinary meetings and communication or referrals.

Add value in MDOs - Als ik naar longbesprekingen kijk, hoe vaak we daar dingen de goede kant op kunnen bespreken, hoe groot de toegevoegde waarde daar is verbaas ik me elke week over. Daar zou ik het liefst al mijn tijd in stoppen.

More time for the complex cases - Door ontwikkelingen in de AI denk ik ook dat we meer tijd moeten besteden aan de complexere gevallen, en dat vind ik alleen maar leuker.

Automate organisation of MDOs - En ik weet dat jullie in de MDO's zitten ook met de schermen, en daar denk ik ook zeker dat je dingen kan automatiseren. Meer op organisatorisch vlak.

More involvement in patient management - we went from people sitting in a dark room to being involved in tumour boards and MDOs. So there is more involvement in patient management than it was before. So the solutions we use need to reflect these changes as well.

Need for screens with MDO functionality - They need to adapt to the fact that we might like to do MDOs from home so maybe have additional functionality built in such as cameras for skyping or videoconferencing.

Growing amount of MDOs - We hebben ook heel veel MDO's, dat is ook een groeiend iets. Die besprekingen nemen gigantisch toe maar dat gaat een keer mis want anders krijgen we ons werk niet af.

Subspecialization, narrowing expertise - Men wordt steeds meer gespecialiseerd (de radioloog). Er zijn steeds complexere beeldvormingen mogelijk, functionele componenten. Er zijn allerlei add-on technieken die worden ontwikkeld waar wij ons in moeten verdiepen dus je kennis wordt steeds smaller omdat er steeds meer kan.

HIVE technology for MDOs - En dan bestaat er zo'n soort technologie zoals het gebeurt in een beehive zodat dan mensen trekken aan verschillende kanten van de conclusie en dan kun je als één speler of meer spelers AI hebben en dan kan een groep naar een conclusie komen, waar je met één of twee mensen nooit was gekomen.

> **Time loss in MDO** - During that meeting, not all of the cases are relevant, so in a meeting of two hours only an hour or a half hour is value added time by me. So there is all that lost efficiency.

Patient contact, MDOs and collecting information become important - de waardering van de werkgever om beelden te bekijken zal minder en minder worden in tien tot twintig jaar. En andere dingen, wat minder gebruikelijk is zoals patiëntencontact, MDO's sturen en informatie verzamelen.

Automated protocolling, more contact - Je kan een deel van het verslagwerk automatiseren en dat wij een soort consument worden over de diagnostiek, zo zie ik dat wel voor me. Dus dan zou het contactaandeel inderdaad groeien.

More time for empathy and complex cases - So we can concentrate more on the aspects that require human interaction: the empathy and complex interpretation side of things.

Growing complexity because of more data - expert

Only about one-third of a radiologist's time is spent interpreting images – paper 2013

Increase of neurological and cardiac issues drive medical imaging market – news

Data becomes more complex - Je hebt niet alleen het apparaat, maar ook de digitale data die daar uit komen. Die data worden steeds complexer. Je krijgt ook quantitatieve data, je kan meer dingen doen en er meer uithalen. Je krijgt nu nog eens de data van het EPD.

Role of radiologist in decision making will increase - ik denk wel dat de radiologen meer beeldgeleide preventie gaan doen en een grotere rol gaan spelen in het beleid, en de keuzes voor de patient.

More contact with specialists and with patient - meer overleg met andere specialisten? Ja, dat ook. Misschien zelfs rechtstreeks met de patient. Dat zal zeker ook wel ergens toenemen

More scans and more complex scans - er komen meer vragen naar de aard van de diagnose. Het wordt allemaal gewoon steeds complexer. Die aanvragen worden steeds meer en meer.

Time gain will result in more time for complex cases - je hebt meer tijd voor complexere zaken.

Contact with specialists will stay - Ik denk dat het fysieke contact nog steeds blijft. Dus het MDO blijf je houden, omdat je de specialist bent op beeldvormingsgebied dus er moet gewoon iemand bijzitten.

More multidisciplinarity - On one hand, the clinical management of patient is getting more and more multidisciplinary, everything is.

Subspecialization - But, on the other hand, the role is getting much more narrow from its part of this multidisciplinarity.

Communication between specialists - Wat een hele belangrijke ontwikkeling is, in de communicatie tussen medische specialisten

Radiologists are used to work as individual but they are judged as an organised whole.

Increase of neurological and cardiac issues drive medical imaging market

Ever growing complexity because of the increasing stream of data, not only in hospitals but also at home

Developments should be used for better diagnoses, contact with patient and contact with referrers

Complexity of the scans increases, radiologists involved in treatment more and more (impact now & will grow)

Aging population (Increased need for healthcare and screening, impact now, will grow)

Rise of chronic diseases: obesity or cancer (Diagnosing becomes more important over screening & complexity of disease grows, impact now, will grow)

Personalized care

A lot of information and data is available per patient. This creates the possibility to tailor the care to be made for the patients as individuals as is described by personalized medicine. This involves regarding the history, the family and the DNA of the patient.

Add value local (patient history matters more) or remote (disease matters more) - Dat we een beetje van beiden hebben. En een beetje je tijd besteden aan dingen waar een mens beter is dan een computer is. En waar een radioloog ter plekke beter is dan een radioloog verder weg

Patient history is a determinant for process - als je meer data nodig hebt, voor ingewikkelde zaken dan is het misschien belangrijker om dat dicht bij de patiënt te doen. Zodat je niet de analyse los trekt van de patiënt zelf en de informatie rondom de patiënt.

Patient contact, MDOs and collecting information become important - de waardering van de werkgever om beelden te bekijken zal minder en minder worden in tien tot twintig jaar. En andere dingen, wat minder gebruikelijk is zoals patiëntencontact, MDO's sturen en informatie verzamelen.

Patient-centred care - Ik denk dat het veel belangrijker is dat we beelden en de vraag die we nu hebben als een deel van het leven van een patiënt met een geschiedenis en een actuele vraag zien. En in die context eigenlijk te beantwoorden

Personalized treatment assisted by radiology - Dus je gaat veel meer die personalized treatment krijgen op basis van de diagnostiek in je behandelperiode, daar kun je veel in verbeteren. Dan hoef je veel te dure medicatie niet te geven aan mensen waarbij je weet dat het toch niet goed aangrijpt en dan kun je veel gerichter behandelen.

Nuclear medicine will expand - Dus dat is iets, daar verwacht ik ook veel van hoor. Dat dat zich gaat uitbreiden. Omdat die functionele informatie geeft vaak wat betere informatie over een bepaald ziekteproces in vergelijking met anatomisch.

Deep learning and radiomics in precision medicine

Driver of DI growth: Ability and achievement of personalized treatment – news

Personalized medicine - De personalized medicine omdat je daar effectief gepersonaliseerde behandeling van een patient gaat kunnen meebepalen.

Radiologists will become data analyst - Ik denk dat we meer data analist moeten worden. We gaan meer de data die we aangeleverd krijgen moeten gebruiken. We gaan onze manier van verslagleggen totaal moeten veranderen.

Analysis by helpers and software, Radiologist will give holistic perspective - Het zal meer in die kant gaan: Dat we de data analyse voor een groot gedeelte overlaten aan helpers en software en dat wij dan uiteindelijk het globale plaatje proberen te zien, meer vanuit een holistisch perspectief.

Person-centred care
System is getting more patient-centred (impact now & will grow)

F: List of scouted technologies

The Content Value Cycle (CVC) is used as a basis for discussion and as a way to separate the technologies into different categories. This list includes all of the technologies and applications stated by the interviewees and found in desk research. Occasionally, use cases, pro's and con's or a short explanation is given. This list also contains patents, the patent number is given next to the patent in brackets together with the name of the assignee at the moment of writing. At the bottom of this list is an overview of the interviewees and the dates of the interviews.

Content creation

- Elastography
- Thermography
- Consumer devices
- Chips
- Portable acquisition devices
- Real-time:
    - 3D endoscopie
    - Echografie/Ultrasound
- Reconstruction:
    - Biplane X-ray
    - Dental revolving scanner
    - CT

Process + Control

- Centralized database (VNA or semi vendor neutral)
- Digital pathology
- TPU (Nvidia)
- Regulatory AI (Datavaribiliteit)
- Re-trials
- AI pre-diagnosis
- Cloud processing
    - Pro: collaboration
    - Pro: Accessibility
    - Con: privacy
    - Con: security
- Network based solutions (Nexxis)
    - Pro: real-time guarantee
    - Pro: uncompressed image quality
- Persistent memory (a new memory tier between DRAM and NAND flash memory that can provide cost-effective mass memory for high-performance workloads)
- Data fabric (frictionless access and sharing of data in a distributed data environment)
- FHIR (format for data in medical environment for interoperability)
- NLP (Automatic interpretation of text and EHR)
- Cloud based image processing system with tracking capabilities (US9430828B2, TeraRecon Inc.)
- Medical evaluation ML workflow and processes (US10198816B2, Virtual Radiologic corp.)
- Automatic diagnosis report preparation (EP3506279A1, Koninklijke Philips NV)

Visualising

- OLED (1 Year)
    - Con: dark room needed
    - Con: burning in of pixels
    - Pro: high contrasts and blacks (HDR)
- HDR
- 3D Displays
    - Competition: Sony
- 3D/VR Planning for surgery
- AR
- Hologram (15-20 Year)
    - Surgical general repetition for complex cases
    - Training purposes
    - Con: diagnoses not practical
- High framerates
    - Moving images
    - Smooth
- QLED (Electro-emissive) (5-8 Year)
- MicroLED (3-5 Year)
    - Microdisplay (AR)
    - Macrodisplay
    - Pro: High contrast
    - Pro: Energy efficient
    - Pro: High luminance
- LCD Dual-layer (HDR) (2 Year)
    - Pro: High contrast (like OLED but without burning problem)
    - Pro: perfect blacks
    - Con: Energy inefficient
    - Con: Dark room needed
- Bonding (Attaching screen to glass front)
    - Better optical spec (less reflection)
    - No condensation

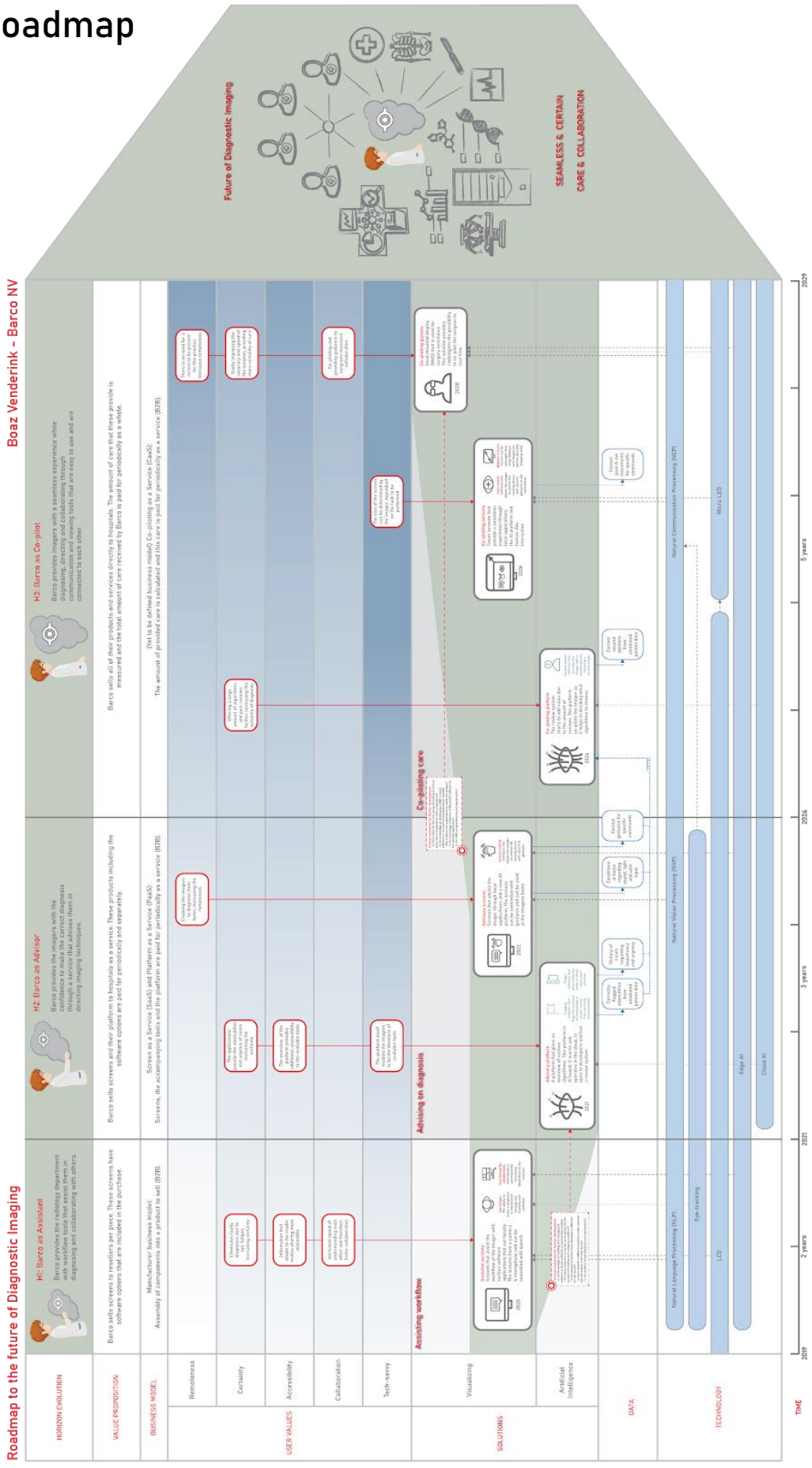
Interacting

- Eye-tracking
    - Tools
    - Filters
    - UI
- Workflow tool on display
- Environment light sensor
    - Automatic adjustment to light
- Proximity sensor
- Iris scanner/Fingerprint scanner
    - Security
    - Privacy
    - Instant login
- 3D eye-tracking (2 Year)
- Automatic contrast/color range adjustment (workflow assistance)
    - Dependent on selection area
    - Dependent on type of scan
    - Dependent on radiologist
- AR + surgery assistance (2-3 Year)
    - Diagnostic
    - HUD with metadata
- 3D touch
- Robotic surgery (embedded)
    - Needs low latency, high processing power and data transfer
    - HMD option: Low comfort for surgeons while providing excellent image quality
- Skintrack (Human-Computer Interaction Institute's Future Interfaces Group)
- Pre-touch (Microsoft Research)
- Automatic camera director (Barco)
- Gesture control (US20190079589A1, Barco)
- Eye controllable screen pointer (US6373961B1, Eye Control Tech Inc)
- Computer controlled by eye tracking (US20180329510A1, Tobii AB)

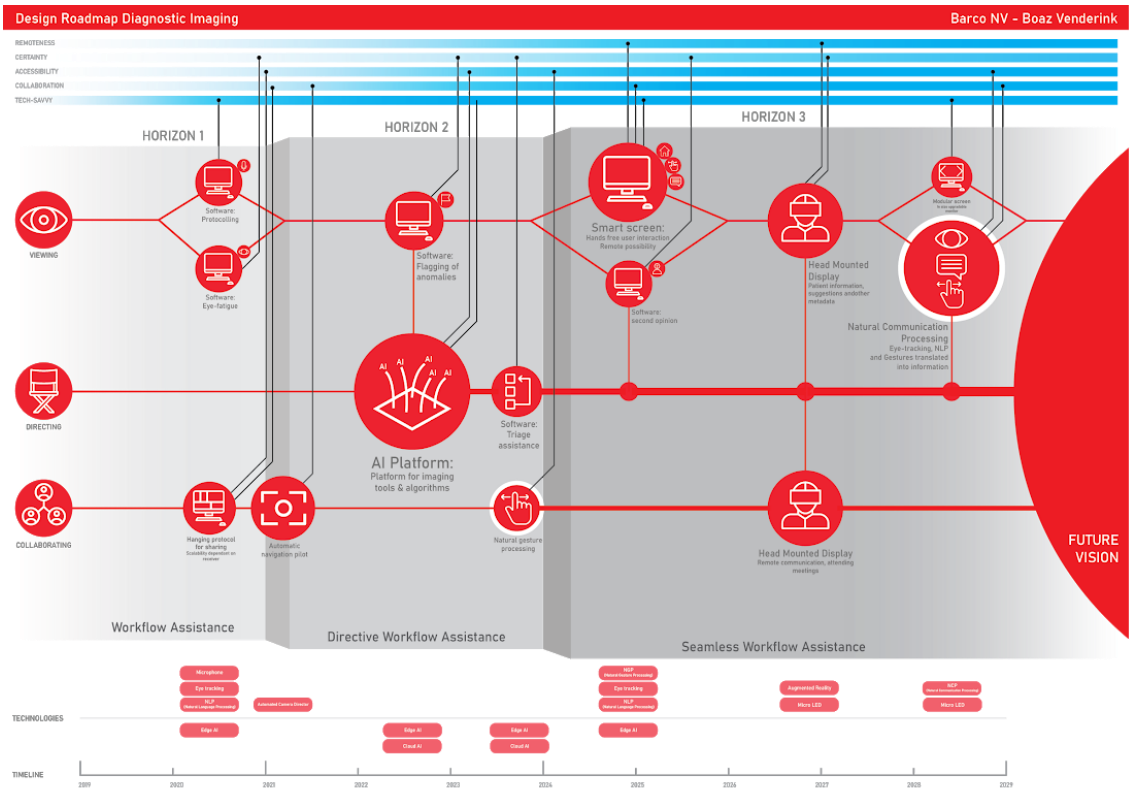
List of interviewees and dates of interviews

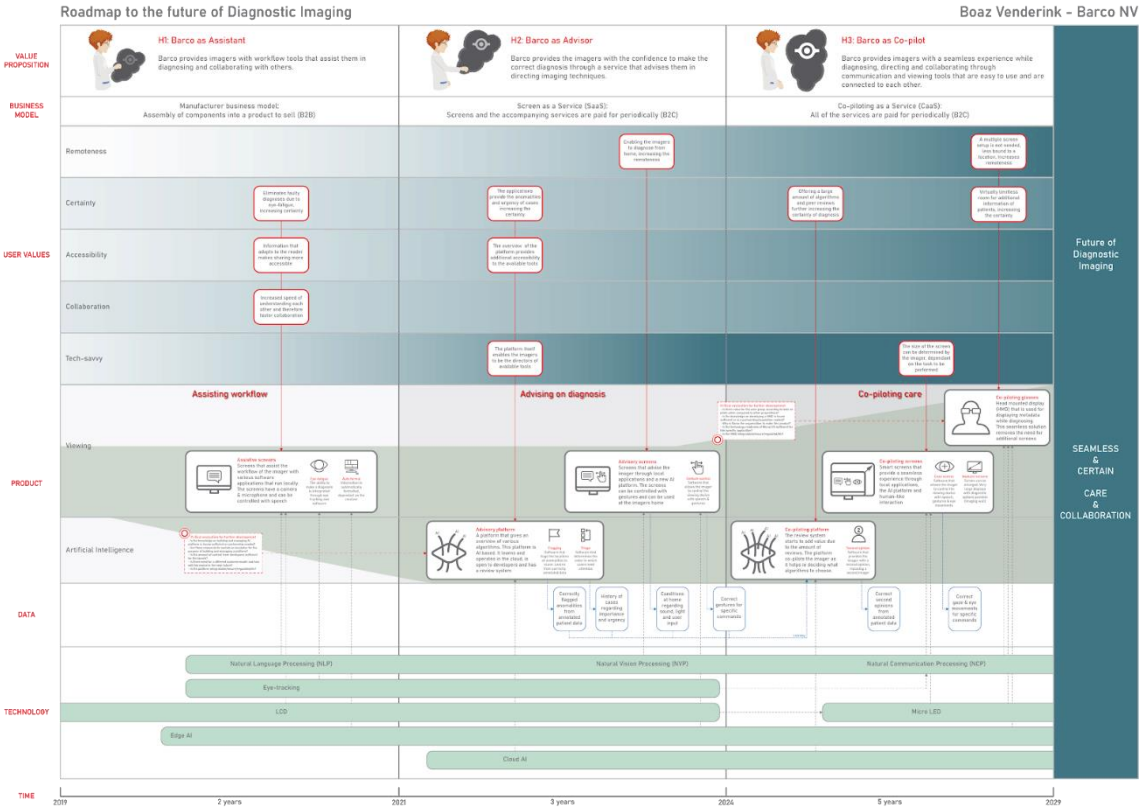
(Vice President Technology and Innovation, personal communication, 25-7-2019); (Sr. Expert, Display Technologies, personal communication, 25-7-2019); (Program Manager Modality Products, personal communication, 1-8-2019); (Expert Engineer & System Architect, personal communication, 2-8-2019/5-8-2019/7-8-2019/8-8-2019/13-8-2019); (VP Technology, personal communication, 5-8-2019/6-8-2019/13-8-2019); (VP Modality Imaging, personal communication, 12-8-2019); (Director Product Management, Network Growth Solutions, personal communication, 21-8-2019); (Sr. Product Manager, personal communication, 27-8-2019)

G: Final Roadmap



H: Evolution of roadmaps





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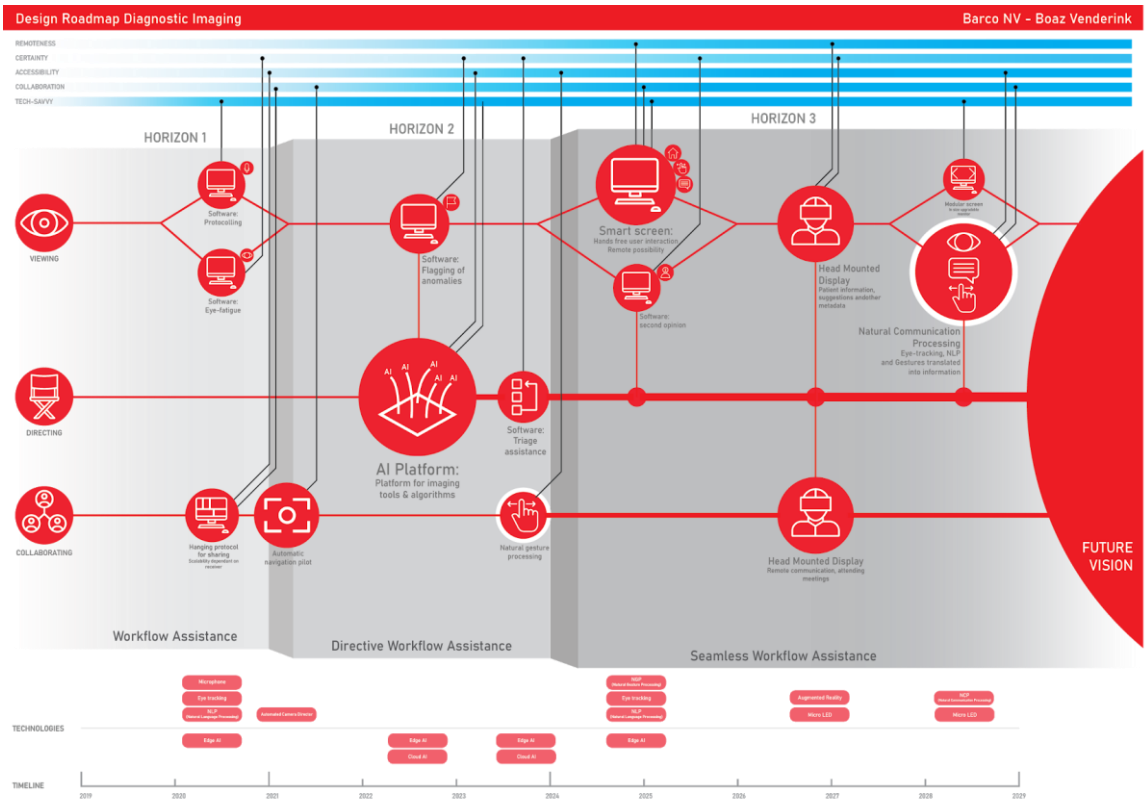
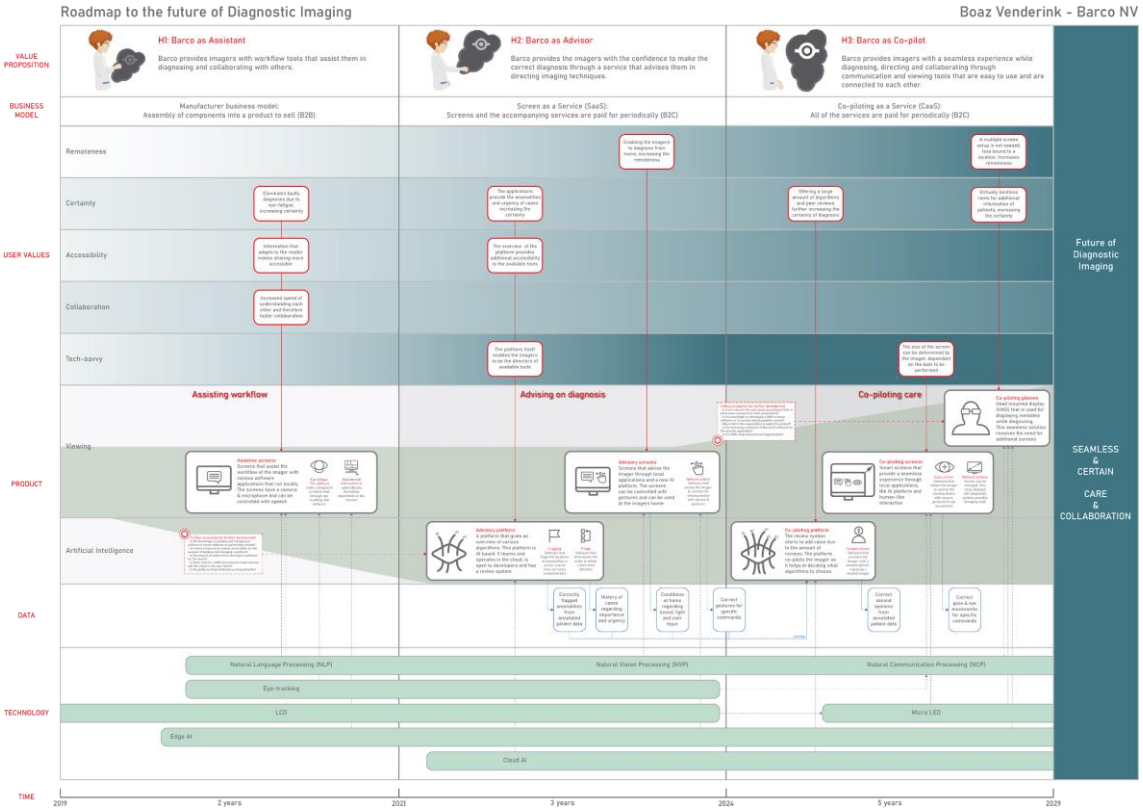
G: Final Roadmap

H: Evolution of roadmaps





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DESIGN FOR our future

TU Delft

PIM 2877 25/4/19

IDE Master Graduation

Project team, Procedural checks and personal Project brief

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

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

USE ADOBE ACROBAT READER TO OPEN, EDIT AND SAVE THIS DOCUMENT

Download again and reopen in case you tried other software, such as Preview (Mac) or a webbrowser.

STUDENT DATA & MASTER PROGRAMME

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

family name	Venderink
initials	B.M. given name Boaz
student number	4152557
street & no.	Annastraat 35
zipcode & city	Delft
country	The Netherlands
phone	0650631961
email	boaz.venderink@gmail.com

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

IDE master(s): ( ) IPD ( ) DfI (★) SPD

2nd non-IDE master: _____

individual programme: - - (give date of approval)

honours programme: ( ) Honours Programme Master

specialisation / annotation: ( ) Medisign ( ) Tech. in Sustainable Design ( ) Entrepeneurship

SUPERVISORY TEAM **

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

** chair	Simonse, L.W.L.	dept. / section:	PIM, MOD
** mentor	Kobus, C.B.A.	dept. / section:	PIM, MCR
2nd mentor	Guy van Wijmeersch		
	organisation: Barco NV		
	city: Kortrijk	country:	Belgium

comments (optional)

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

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

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

Procedural Checks - IDE Master Graduation

TU Delft

APPROVAL PROJECT BRIEF

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

chair Simonse, L.W.L. date 23 - 4 - 2019 signature

CHECK STUDY PROGRESS

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

Master electives no. of EC accumulated in total: 27 EC

Of which, taking the conditional requirements into account, can be part of the exam programme 27 EC

List of electives obtained before the third semester without approval of the BoE

✓ YES all 1st year master courses passed

NO missing 1st year master courses are:

name D. Keursler date 26 - 4 - '19 signature

FORMAL APPROVAL GRADUATION PROJECT

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

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

Content: ✓ APPROVED NOT APPROVED

Procedure: ✓ APPROVED NOT APPROVED

comments

name A Hummel date 14-5-2019 signature

Initials & Name B.M. Venderink Student number 4152557

Title of Project A Roadmap to the future of Healthcare in Barco