Aalto University
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A Digital Society for All

Defining Accessibility Practices in Agile Software Development

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ABSTRACT OF
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Digital products and services have started to replace their physical counterparts during the last two decades. Meanwhile, more than 15% of the world's population lives with some form of disability which has led to societal, industrial and academic interest to improve accessibility. Practical knowledge on accessibility implementation could support teams and software organisations in their accessibility aspirations and shed light on an under-researched but still current topic.

The aim of this study is to define processes and practices that may promote accessibility realisation in the context of agile software development. This study is a combined embedded single-case study and constructive research. First, employees of the case company were interviewed (N=20) and observed, particular emphasis being on three product teams. Additionally, the accessibility of three digital products of the aforementioned teams was evaluated. Second, an accessibility improvement process was constructed and some of its first steps were evaluated.

According to a combined literature review and empirical research, it appears that the current state of accessibility is weak and accessibility understanding varies greatly within digital practitioners. An existing empathy link to people with disabilities may have a significant impact on understanding the importance of accessibility and its consideration in work. The current challenges include lack of knowledge, understanding and resources as well as present practices. Organisations and practitioners could be motivated through economic, societal and professional and qualitative factors. Moreover, accessibility knowledge, understanding and resources as well as business and management support may enable accessibility realisation.

The Accessibility Improvement Process is proposed to embed accessibility into routines of agile teams and organisations. After an organisation has found its motivation for accessibility implementation and the enablers for continuous accessibility have been ensured, a two-fold accessibility process cycle is recommended for sustainable implementation. This is a pioneering empirical study of developing accessibility processes and practices for teams and organisations.

Keywords: accessibility, digital accessibility, web accessibility, improving accessibility, accessibility practices, accessibility processes

Language: English

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Digitaaliset tuotteet ja palvelut ovat alkaneet korvata fyysisiä vastinkappaleitaan 2000-luvun aikana. Samalla yli 15% maailman väestöstä elää jonkinlaisen vamman kanssa. Tämä on johtanut yhteiskunnalliseen, teolliseen ja akateemiseen mielenkiintoon saavutettavuuden parantamiseksi. Käytännön tieto saavutettavuuden toteuttamiseen liittyen tukisi tiimejä ja organisaatioita saavutettavuustavoitteissa ja valaisisi vähän tutkittua mutta ajankohtaista aihetta.

Tämän tutkimuksen tavoite on määritellä prosesseja ja käytänteitä, jotka voivat edistää saavutettavuuden toteutumista ketterän ohjelmistotuotannon kontekstissa. Tutkimus on yhdistelmä sulautettua kertatapaustutkimusta ja konstruktiivista tutkimusta. Aluksi tapausyrityksen työntekijöitä haastateltiin (N=20) ja havainnoitiin huomion ollessa kolmessa tuotetiimissä. Lisäksi kyseisten tiimien kolme digitaalista tuotetta saavutettavuusarvioitiin. Lopuksi saavutettavuuden parantamisen prossessi konstruoitiin ja sen ensimmmäisiä askelia kokeiltiin.

Kirjallisuuskatsaus ja empiirinen tutkimus osoittavat, että saavutettavuuden nykytila on heikko ja sen ymmärtäminen vaihtelee suuresti digitaalisten ammattilaisten keskuudessa. Empatialinkillä voi olla merkittävä vaikutus saavutettavuuden merkityksen ymmärtämisessä ja sen työssä huomioimisessa. Tiedon, ymmärryksen ja resurssien puute sekä nykyiset käytänteet luovat haasteita. Taloudelliset, yhteiskunnalliset sekä ammatilliset ja laadulliset tekijät voivat motivoida toimenpiteisiin. Saavutettavuustieto, -ymmärrys ja -resurssit sekä liiketoiminnan ja hallinnon tuki voivatkin mahdollistaa saavutettavuuden toteutumista.

Saavutettavuuden parantamisen prosessia esitetään saavutettavuuden sulauttamiseksi osaksi ketterien tiimien ja organisaatioiden toistuvia toimintatapoja. Kun organisaation motivaattorit on tiedostettu ja mahdollistajat jatkuvalle saavutettavuudelle on varmistettu, kaksiosaista prosessiympyrää suositellaan kestävän toteutuksen varmistamiseksi. Tämä on uraauurtava empiirinen tutkimus saavutettavuusprosessin ja -käytänteiden kehittämiseksi tiimeille ja organisaatioille.

Asiasanat:	saavutettavuus, digitaalinen saavutettavuus, verkkosaavutettavuus, saavutettavuuden parantaminen, saavutettavuuskäytänteet, saavutettavuusprosessit
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Töölö, 25 November 2019

Helinä Hakala

Initialisms

This is a list of initialisms for terms that are used in this thesis.

B2B	Business-to-Business
B2C	Business-to-Consumer
CSR	Corporate Social Responsibility
DS	Design System
EAA	European Accessibility Act
HCD	Human-Centred Design
HCI	Human-Computer Interaction
HTML	Hyper Text Markup Language
ICT	Information and Communication Technology
PDCA	Plan-Do-Check-Act
SEO	Search Engine Optimisation
UCASD	User-Centred Agile Software Development
UCD	User-Centred Design
UI	User Interface
UX	User Experience
WAD	Web Accessibility Directive

Contents

Chapter 1

Introduction

Since the first web page was launched in 1990, the growth of Internet users has accelerated. In only a decade, the worldwide Internet penetration rate grew from 0.05 percent to almost 7 percent (Murphy and Roser, 2019) and today, more than half of the population worldwide has access to the Internet (DataReportal, 2019). In developed countries, the Internet penetration rates are even higher – in Northern Europe and Northern America, the usage rate reached 95 percent in early 2019 (DataReportal, 2019).

At the same time, more and more services have made their way to the Internet and currently many online services are no longer just means of augmenting physical services (see e.g. Wentz et al., 2018). Digital services have started to replace their physical counterparts as people are expected to have access to the Internet. However, being able to access the Internet is only one part of accessing digital products. Any physical, sensory or cognitive impairment can complicate the use of a digital service and even restrict its use completely. This has led to the topic of digital accessibility becoming of academic interest and it has been researched increasingly since the mid-2000s (see e.g. Freire et al., 2007).

According to the World Health Organization (2011), 15 percent of the world's population are estimated to live with some form of disability. This is higher than previous estimates from the 1970s that suggested around 10 percent. Due to the aging population, the number has been predicted to increase substantially in the near future (European Commission, 2015). Combined with the growing significance of digital services, governing bodies across the world have become aware of the importance of design-for-all ideology not

only in physical settings but also in the digital world, and started to bring web accessibility into their legislation (see e.g. Peters and Bradbard, 2010).

There are tangible visual, technical and content-related guidelines and checklists (see e.g. WCAG 2.1 by W3C, 2018a) that can help software teams to increase the accessibility of their products. However, they are limited to rules and concrete criterion without further implications on how to apply them in a real-life project environment. Accessibility audits are often recommended to begin the process with existing software products, whereas sustainable ways of factoring accessibility into project work are not promoted. In addition, assessed information on improving accessibility in the context of a software development team or an organisation cannot be found easily. This is the case with both industrial and academic literature and, thus, improving processes related to accessibility can be difficult without benchmarks or references.

The aim of this thesis is to ascertain how agile software development team and organisations can improve the accessibility of their web applications sustainably. This can help organisations and production teams to find ways of working that support the creation of an accessible environment for users and, hence, address requirements set in legislation on web accessibility around the world. From a theoretical point of view, this study can approach an under-researched topic that has become increasingly current.

This qualitative study was conducted as a combination of (i) a *case study* within a large telecommunications and software services company to assess the current ways of working relating to accessibility and (ii) *constructive research* to form a process for improving accessibility of digital products and services based on findings in the case study part. At the end, some of the first steps of the process were tested together with product teams to tease out some first hints about the effect of the process.

In this chapter, the background and motivation of this study are described in more detail. Then, the research questions are introduced and the scope is defined. Finally, the research approach of the thesis is laid out.

1.1 Background and motivation

During the 2000s, the western world became increasingly aware of inclusion in the context of Human-Computer Interaction (HCI). As computers and the Internet became part of everyday life for a continuously growing number of

people, it became evident that the content and services shared over the Internet should be "*accessible by anyone, anytime and anywhere*" (Stephanidis, 2001), regardless of their abilities or skills. The Stockholm Declaration of the European Institute of Design and Disability (EIDD) voiced the importance of Design for All (DfA) process in Europe (EIDD-Design for All Europe, 2019), while Universal Design ideology in the USA paved the way to accessibility across the Atlantic (Institute for Human Centered Design, 2019).

The continuous digitalisation of services combined with the inclusive design movement across the world has inspired governing bodies to start introducing accessibility into their legislation through accessibility and equality acts as well as some concrete standards and guidelines to support the realisation of web accessibility. Thus, accessibility in the context of digital products and services has also been researched increasingly during the last decade, especially in the form of accessibility evaluations. These studies usually take one or more of three key aspects as their main focus, as follows:

(i) The first aspect is the business area or service type, such as e-commerce (Gonçalves et al., 2018), online banking (Wentz et al., 2018) or education (Rodríguez et al., 2017). These studies often approach their topic with an accessibility assessment of which results can be extended to other similar products.

(ii) The second angle is the application or device type that is being used for accessing the product. Web applications (Gonçalves et al., 2018) and mobile applications (Carvalho et al., 2018; Yan and Ramachandran, 2019) have been the most commonly used application types during the 2010s.

(iii) The third aspect is the disability type that a person may have, out of which different visual impairments, including blindness, seem to be one of the most researched impairments related to web accessibility (Carvalho et al., 2018; Giraud et al., 2018; Gonçalves et al., 2018).

Accessibility has also been researched from the point of view of both practitioners and organisations, although it seems that it is not as common a research angle. The previous research covers topics such as accessibility-related beliefs (Farrelly, 2011; Vollenwyder et al., 2019; Yesilada et al., 2015) and motivations (De Andrés et al., 2010; Farrelly, 2011; Leitner et al., 2016; Martínez et al., 2014; Vollenwyder et al., 2019; Yesilada et al., 2015). In addition, some enablers (Farrelly, 2011; Katsanos et al., 2012; Leitner et al., 2016; Power et al., 2018; Yesilada et al., 2015) as well as obstacles (Farrelly, 2011; Katsanos et al., 2012; Lazar et al., 2004; Leitner et al., 2016) for

accessibility implementation have been identified.

There are case studies of both successful and less successful projects where change of some sort has been facilitated (Adams and McNicholas, 2007; Burn and Robins, 2003; Nelson, 2003; Nikitina et al., 2012). However, no studies regarding an organisational or team-level transformation on accessibility implementation practices have been found. Similarly, there seems to be little or no research on accessibility implementation processes and practices. Thus, potential or successful ways to implement accessibility in product teams and organisations may not have been researched nor disclosed yet.

1.2 Research questions and scope

The aim of this study is to *define processes and practices that may promote accessibility realisation in agile software development* which is also the scope and context for this thesis. In order to reach the aforementioned aim, the following research questions are presented:

RQ1: How is digital accessibility achieved today...

(i) ... from the perspective of digital products and services?
(ii) ... from the perspective of digital practitioners (understanding, consideration, perceived challenges)?

RQ2: What factors may motivate and enable accessibility realisation?

The first research question (RQ1) aims to explore the current state of digital accessibility and it is approached both through literature review and empirical case-study research. Understanding the initial state of accessibility, practitioners' attitudes and potential underlying challenges is required so that any implications for the target state of accessibility can be considered.

The first part of question (ii) focuses on the accessibility of digital products and services. The main source of information is a literature review of existing accessibility evaluations to gain a holistic understanding of the current state of accessibility. It is supported by a minor accessibility evaluation of three web services of the case company.

The second part of RQ1 (ii) addresses how digital practitioners understand accessibility and take it into consideration and what challenges they have perceived to lie in implementing accessibility in practice. Some previous studies have interviewed practitioners to establish their perspective on accessibility. Moreover, practitioner interviews conducted during the case study increase the depth of findings. It appears that there is little research that combines accessibility evaluations and practitioner interviews to investigate how the experienced and actual levels of accessibility are related to each other. This study aims to also provide first indications of the current state of that relationship.

While RQ1 focuses on the initial state of accessibility realisation, the second research question (RQ2) reflects on potential ways to impact accessibility implementation to increase the accessibility of digital products and services. This is approached by researching, firstly, motivators that may increase the value of accessibility implementation in the eyes of practitioners and other organisational stakeholders and, secondly, enablers that may promote accessibility implementation in practice. Thus, motivators and enablers may help to create a fruitful and receptive basis for teams and organisations to start accessibility implementation (the target state). RQ2 is answered through a literature review and empirical research.

The answers to RQ1 and RQ2 lay the ground for defining practices for accessibility implementation which is the second part of the study, carried out as constructive research. An accessibility improvement process is created to support digital practitioners, agile software development teams and organisations in their accessibility aspirations. Finally, some of the first steps of the process are carried out and evaluated in the context of a large Finnish telecommunications and software services company.

1.3 Research layout

The nature of this study is a qualitative inductive study. It is approached using case-study and constructive research to, first, gain an understanding of the baseline of accessibility implementation and related challenges and, second, create an accessibility-promoting process for teams and organisations based on that understanding. Finally, initial process experimentations are executed. The research design supports the combination of investigative

and constructive objectives and contributes to the overall understanding of sustainable accessibility consideration.

In the first part of the study, the current state of digital accessibility realisation is explored through three (3) production teams in the context of a Finnish telecommunications and online services company. To collect data, thematic interviews were performed, supported by participant-observation. The research material consists of sixteen (16) development team member interviews conducted in three separate product teams and four (4) organisational context interviews. Although the selected development teams are part of the same company, they are highly independent and have chosen their methods and ways of working themselves. In addition, an accessibility analysis was conducted on three (3) digital services of the case company to confirm team and organisation-based observations. The data was assessed both formatively during the fieldwork period and summatively after the interviews.

The second part of this study concerns creating the construction. Its aim is to form a process for the sustainable creation of accessible digital products and services based on findings examined in the previous part. In addition, existing research on accessibility implementation and organisational change as well as maturity models and iterative ideologies are used as tools to compose the construction.

Finally, to evaluate the designed process, some of the first steps of the process were tested together with production teams to get the first hints about the effect and credibility of the process. Thus, six (6) experiments were carried out followed by four (4) email interviews. Due to time restrictions of the research this part provides only a small glimpse into the potential of the process instead of assessing it completely.

Next, the background for the research is established in Chapter 2. Then, the whole material, data extraction process and analysis are described in more detail in Chapter 3. The details of the case in its entirety can be found in Chapter 4, while Chapter 5 presents the results of the study. After that, the findings are discussed in Chapter 6, followed by the introduction of the constructed process in Chapter 7 and final conclusions in Chapter 8.

Chapter 2

Conceptual Background

This chapter contains the conceptual background for this thesis, based on both academic literature and industry standards and definitions. The key concept of *accessibility* is defined and some accessibility guidelines, standards and evaluation tools as well as related legislation are introduced. Then, the concept of *agile software development* is defined and the roles of user-centred design and accessibility in agile software development are described. Finally, *organisation-related themes* such as change facilitation, maturity models, design system and business drivers and risks of accessibility are discussed.

2.1 Accessibility

In this section, both the theoretical background of accessibility in the digital context as well as related standards, guidelines, evaluation methods and legislation are described. Following the trend in current accessibility research, the accessibility definitions of the International Organization of Standardization (ISO) and the World Wide Web Consortium (W3C) are used as the base for this thesis. As the current industrial and political movements have an impact on research related to web accessibility, it is also important to discuss them for a holistic contextual understanding.

Google Scholar[1] was mainly used to search for papers published in scientific journals or conferences. Currently, different terms are used to generally refer to the accessibility of digital products and services, including *accessibility*,

[1]Google Scholar: `https://scholar.google.com/`.

e-accessibility, *digital accessibility* and *web accessibility*. Therefore, the aforementioned four terms were all used to search material related to the topic, web accessibility as the main keyword due to its online frequency in comparison to others. Different combinations of the aforementioned terms and the following keywords were used to find articles related to the state of accessibility as well as influencing factors and processes: *improving*, *process*, *challenges*, *motivation*, *practitioners* and *business*.

In addition to the mixed terminology, another problem with finding highly relevant literature was the focus of many current accessibility studies. Although there are several works on accessibility in the digital context, no studies that focus on improving the state of accessibility from the organisation, team or practitioner's point of view have been found. However, many studies focus on finding accessibility-related issues in existing websites and applications, as well as reasons behind inaccessibility and motivation to implement accessibility. Other common research angles focus on testing and comparing existing accessibility evaluation tools (automatic and semi-automatic) and metrics (existing and newly constructed) with one another.

The main timeframe for the search was the years 2010–2019. The timeframe was chosen to form an impression of recent studies related to accessibility of digital products and services as well as accessibility-related practicalities. After an initial search, it was found that there were some areas that would benefit from a wider academic context. Thus, another search that covered the 1990s and 2000s took place to widen the perspective when supportive material was needed.

For this thesis, more than 300 studies related to web or digital accessibility were screened. Altogether 27 of them were selected to be reviewed in more detail on account of their relevance to the research problem of this study. Article quantities and distribution around different themes can be found in Table 1.

Screened papers	Reviewed papers	Topics			
		Accessibility evaluations	Evaluation tools and guidelines	Accessibility influencers	Other accessibility focus
300+	27	8	4	7	8

Table 1: Numbers of accessibility articles screened and reviewed as well as the main focused topics of the reviewed papers.

2.1.1 On the definition of accessibility

Inclusive design and *accessibility* in human-centred design (HCD) and information and communication technology (ICT) started to rise in literature in the early 2000s (see Stephanidis, 2001). Stephanidis, 2001 highlights that terms such as *Design for All* and *Universal Design* were not new in the beginning of the 2000s, but can be traced to several engineering disciplines with implementations in the physical world, such as interior design and landscape architecture.

According to Stephanidis (2001, p. 3), the aim of the human-computer interaction (HCI) "*is to ensure the safety, utility, effectiveness, efficiency, accessibility and usability of such systems*". This indicates that the close relation between accessibility and HCI. Due to the popularisation of digital services, Stephanidis (2001, p. 3) states that "*a diverse user population with different abilities, skills, requirements and preferences, in a variety of contexts of use, and through a variety of different technologies*" should be able to use and access content through user interfaces (UI). Similarly, the United Nations (UN) has underlined the importance of ensuring access to and human rights on the Internet as well as online freedom (UNHRC, 2018).

In some recent studies (Gonçalves et al., 2013; Wentz et al., 2018), accessibility is defined according to the definition of the W3C. Some others (Giraud et al., 2018; Gonçalves et al., 2018; Rodríguez et al., 2017) follow a definition from the ISO. However, there are also many recent studies (see e.g. Aizpurua et al., 2016; Carvalho et al., 2018; Song et al., 2018; Vigo et al., 2013; Yan and Ramachandran, 2019) where the meaning of accessibility is not specified. In these papers, the Web Content Accessibility Guidelines (WCAG) by W3C (2018a) are often introduced as a widely accepted set of accessibility-supporting directions (see e.g. Song et al., 2018; Carvalho et al., 2018) and even used to evaluate the accessibility of their target products or services (see e.g. Vigo et al., 2013). It is argued that although WCAG offers a solid base for accessibility evaluation, it can only be used to find approximately half of the possible accessibility issues (Aizpurua et al., 2016; Power et al., 2018). W3C also concedes that WCAG standard is not omnipotent and cannot answer needs presented by all possible disabilities (W3C, 2018a). Still, it is likely that in some cases the unmentioned definitions of accessibility are similar to the one of W3C due to the link to WCAG.

ISO uses both an overall definition of accessibility as well as a definition in the context of interactive systems in its *Ergonomics of human-system interaction*

(9241) multipart standard. In general, accessibility means the "*extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user ... needs, characteristics and capabilities to achieve identified goals in identified contexts of use*" (ISO, 2017, p. 2). Within interactive software systems, accessibility is defined as the "*usability of a product, service, environment or facility by people with the widest range of capabilities*" (ISO, 2008, p. 2). By emphasising the usability orientation, a link is created to the part of the standard where human-centred design for interactive systems is discussed, and where accessibility is also brought up repeatedly (ISO, 2019).

W3C (2019b) concentrates solely on web accessibility in its accessibility standards and guidelines and, therefore, the outline of accessibility is more precise. Web accessibility is specified as a state in which websites and other technologies are designed and developed in a way that people with disabilities can perceive, understand, navigate and interact with the Web as well as contribute to it (W3C, 2019b). Additionally, it is highlighted that accessibility could also benefit users without disabilities, including elderly people and people who suffer from a temporary disability such as a broken arm or lost glasses (W3C, 2019b).

In addition to the link between accessibility and *usability* established by ISO, accessibility is commonly researched together with usability or user experience (UX) (see e.g. Carvalho et al., 2018; Giraud et al., 2018; Gonçalves et al., 2018). Rodríguez et al. (2017) note that usability and accessibility are complementary to one another. Moreover, Aizpurua et al. (2016) study the link between accessibility and usability. They observed eleven (11) participants with a visual impairment using websites in use cases that replicated natural ones (Aizpurua et al., 2016). Aizpurua et al. (2016) conclude that there is a significant correlation between web accessibility and user experience, which suggests a close relation between the two. Moreover, it has been stated that accessibility can result in "*a wider set of benefits for everyone*" (Peters and Bradbard, 2010, p. 206).

Prior empirical research (Leitner et al., 2016; Moreno and Martinez, 2013; Richards et al., 2012) also indicates that there is a connection between *search engine optimisation* (SEO) and web accessibility. SEO aims to gain higher visibility on online search results and, thus, increase the visitor numbers on a website (Moreno and Martinez, 2013). According to some studies, it seems that improving SEO can also enhance accessibility with the same effort (Moreno and Martinez, 2013; Richards et al., 2012). Similarly, improving

accessibility has been reported to lead to better ranking in search engine results and to increase website traffic (Leitner et al., 2016).

In this study, the terms *accessibility*, *web accessibility* and *digital accessibility* are used interchangeably. They refer to a state of a digital product or service in which that product or service can be used by the widest possible group of users, including persons with for example cognitive, physical or sensory disabilities, in a usable manner. However, it is important to understand that as every person is different from one another, it is most likely impossible to implement a product or service that can be fully accessed by anyone. Thus, when improving accessibility or creating accessible products and services are discussed in this thesis, accessibility also refers to a certain level of fulfilled criteria which are defined in the context of a certain team or organisation.

2.1.2 Standards and guidelines

There are several bodies that offer standards and guidelines for digital accessibility, including both web and mobile accessibility. Two of the best known entities worldwide are ISO and W3C. Their standards are used to both define accessibility and help to create accessible products and services. Those standards also consist of guidelines that can be used to measure success in achieving accessibility. Moreover, there are legislation-based standards such as Section 508 of the US Federal Government as well as guidelines from independent organisations that are used to develop more accessible software and evaluate accessibility.

According to Ellcessor (2010), there were several factors that led to the initial ascent of the first concrete digital accessibility standards, WCAG and evolved Section 508, at the turn of the millenium (1999 and 2001, respectively). First, the rise of mobile telecommunications during the 1990s led to ongoing work on accessibility in that context. Second, attention to the civil rights of people, regardless of their abilities, had started to increase. Finally, the continuous development of the Internet as well as growing enthusiasm for its possibilities as a truly accessible platform for information and communication had continued to push boundaries on an ideological level (Ellcessor, 2010). The two standards were also able to create a fruitful base for future accessibility guidelines and inclusivity work.

Web Content Accessibility Guidelines (WCAG)

Due to its specific focus on improving web and mobile accessibility, W3C can be seen as one of the most relevant organisations in the area. W3C established its Web Accessibility Initiative (WAI) on 7 April 1997 which concurrently kicked off the development of WCAG (Ellcessor, 2010). After two years, the first version of the normative WCAG was released in 1999 (Ellcessor, 2010). Since then, there have been two updated versions – WCAG 2 was published in 2008 and its most recent extended edition, WCAG 2.1, in 2018 (W3C, 2018b). WCAG 2.0 has also been approved as an ISO standard (ISO/IEC 40500:2012) which can make it easier for countries to adapt WCAG as a part of their legislation (W3C, 2018b).

WCAG 2.1 is structured in four layers (Figure 1). The highest level consists of the **four principles** that guide the entire set of instructions (W3C, 2018a):

- Perceivable – "*Information and user interface components must be presentable to users in ways they can perceive*";
- Operable – "*User interface components and navigation must be operable*";
- Understandable – "*Information and the operation of user interface must be understandable*"; and
- Robust – "*Content must be robust enough that it can be interpreted by by [sic] a wide variety of user agents, including assistive technologies*" (W3C, 2018a).

The second level under the principles consists of **13 guidelines** that provide concrete goals for achieving the principal states. These include, for example, having text alternatives for non-textual content (1.1) and ensuring distinguishable (1.4) and predictable (3.2) content as well as keyboard (2.1) and assistive technology (4.1) access for users. The guidelines act as overall objectives for accessible design, development and content creation, supporting practitioners in their work. (W3C, 2018a)

Each of the guidelines is supported by multiple **success criteria**, altogether **78** of them. They are more defined rules for practitioners to follow in order for them to achieve a certain level of accessibility. For example, the structure and relationships on a web page should be programmatically defined (1.3.1), or a web page should have descriptive titles for the sake of understanding the purpose of the page (2.4.2). Each of the success criteria have a defined

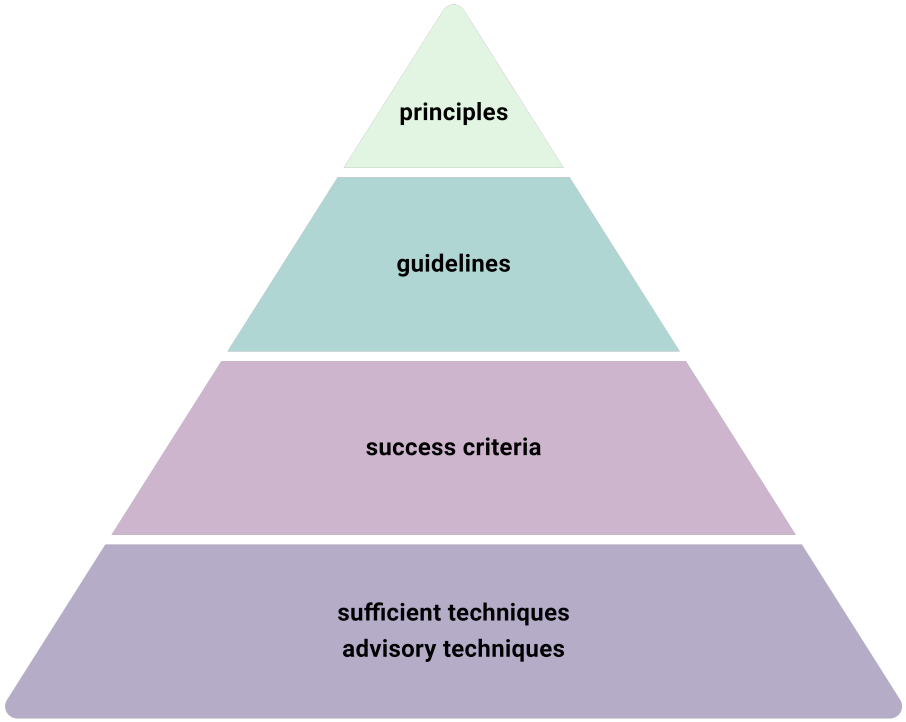

Figure 1: The four layers of WCAG from most abstract to detailed.

conformance level: A, AA, and AAA. The level A is the ground level, ensuring a certain minimum level of accessibility from the W3C point-of-view. The AA is the middle level that is often used as a threshold in accessibility legislation that takes WCAG as the definition of accessibility. The highest level is the AAA. Instead of more general use cases and elements, the success criteria with the conformance level AAA aim to support users in quite specific scenarios. (W3C, 2018a)

Finally, there is the layer of **sufficient and advisory techniques** that are offered in a separate document. They are even more detailed than the success criteria, going into specific examples of how the success criteria could be answered. They can be related to visual or text content, or even a specific technology or markup such as HTML. Examples can support digital practitioners, especially when they are still trying to learn about accessible means of designing, developing or creating content. (W3C, 2018a)

There are multiple factors that need to be taken into account in software development and production. On the technical side, there are several levels

that range from information architecture to the visual details of user interface (UI) elements. Moreover, software design does not only include the visual outlook of a software, but the entire user experience and the logic for using and navigating it. The aforementioned aspects complement the content of the application: text, images, sounds, videos and any interactive elements.

WCAG and its conformance levels have been internationally accepted as a benchmarking tool for accessibility status. Moreover, W3C offers a format called Accessibility Conformance Testing (ACT) to support content creators in their efforts to test conformance to WCAG (W3C, 2019a). However, the documentation of the standard is extensive which can make it challenging to glance through. Hence, several private and public entities, for example IBM[2] and different governmental bodies[3], have created web accessibility checklists based on the guidelines and success criteria of WCAG to support designers, developers and content creators in their work. Similarly, test tools have been created to support especially the programming part of the development process.

Due to the diversity of people and disabilities, accessibility is a perspective that should be considered during all phases of product and service creation. Therefore, WCAG aims to approach different kinds of needs in its principles, guidelines and criteria. The relationship between the different parts and aspects of software and the four WCAG principles are reflected in Figure 2.

ISO 9241-171: Guidance on software accessibility

The ISO standard 9241 is a multi-part standard concerning the ergonomics of human-system interaction. Its different parts have different targets, from software ergonomics to physical input devices. Digital accessibility is highlighted both from the aspects of software ergonomics and human-computer interaction, making accessibility an inseparable part of them from the ISO perspective. *Part 171: Guidance on software accessibility* (ISO, 2008) is the part that has the strongest take on accessibility.

The standard approaches accessibility through principles, highlighting equitable use, sustainability for the widest use range and robustness. They are

[2]IBM Accessibility Checklist: `https://www.ibm.com/able/guidelines/ci162/accessibility_checklist.html` [Accessed: 15/10/2019].

[3]See e.g. guidelines on the website of Government of South Australia: `https://accessibility.sa.gov.au/introduction/accessibility-guidelines` [Accessed: 15/10/2019].

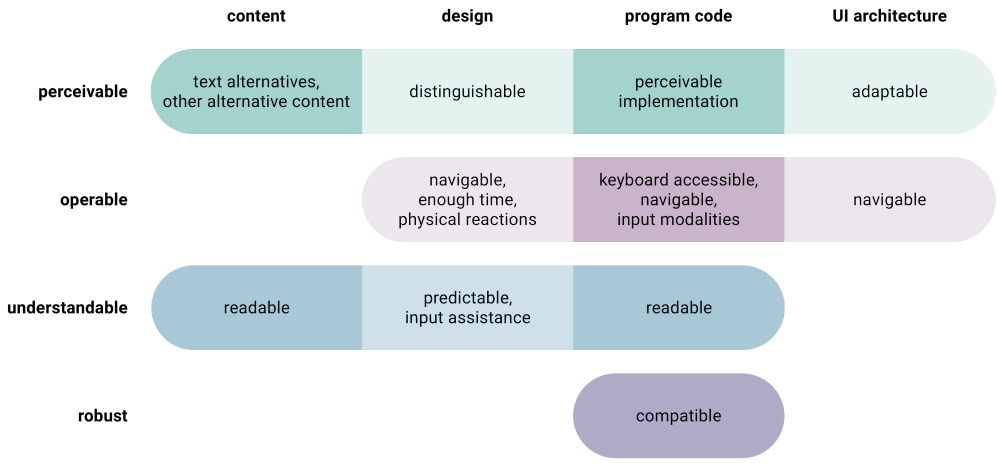

Figure 2: Relation of the four WCAG principles to different parts and aspects of digital products and services.

followed by guidelines that each consist of a description of the guideline, clarifying notes and general UI examples for grasping the meaning of it. Some 62 of these guidelines are also requirements for a software to claim conformance of the part 171. (ISO, 2008)

Other standards and guidelines

In addition to the standards set by internationally acknowledged organisations, legislation in different countries, unions and federations offers frameworks for accessibility realisation. While some of them do follow the aforementioned standards, especially WCAG[4], others set their very own standards for the required parties to follow[5]. One of the best known legislation-based standards is Section 508 by the US Federal Government that applies to federal sector agencies in the USA.

There are also other guidelines and standards that have been acknowledged within the software industry. One that has also been referred to in recent work (Carvalho et al., 2018; Yan and Ramachandran, 2019) is the set of

[4]E.g. the Web Accessibility Directive (2016/2102) by the European Union (2016) and Americans with Disabilities Act.

[5]E.g. Section 508 of the US Federal Government and the European Accessibility Act (2019/882) by the European Union (2019).

web and mobile guidelines adopted by the British public service broadcaster BBC. The company's aim for their standards is to ensure that their own digital products are available for the widest possible audience and to support developers with accessibility efforts simultaneously (BBC, 2014).

The ideology and requirements of WCAG, ISO 9241-171 and many of the other standards and guidelines overlap to some extent. Likewise, their limits are often similar to each other. For instance, they do not typically address cultural or language aspects deeply, not to mention challenges caused by illiteracy or cognitive disabilities (Ellcessor, 2010). Also in the case of sensory or physical disabilities, the existing guidelines can fall short (Power et al., 2018).

Relationship between guidelines and experienced level of accessibility

Power et al. (2018) researched the relationship between the following of guidelines to achieve a certain state of accessibility and working with users with disabilities to find accessibility issues. According to them, only half of the problems that users encountered were covered by WCAG guidelines. This lead them to a conclusion that potential implementations for fixing accessibility problems should be evaluated with users with disabilities to create veritably accessible software (Power et al., 2018).

In their study, Aizpurua et al. (2016) looked into the relationship between a selection of UX attributes and web accessibility. They introduced to their blind test participants four websites with different WCAG 2.0 success-criteria pass rates. Aizpurua et al. (2016) learnt that perceived accessibility seems to be connected to most UX attributes. The participants may associate the experience of accessibility with good UX – accessible websites are those which are perceived to be "*good, appealing and beautiful*" – and vice versa. Their results indicate that the experienced accessibility is not only related to task-oriented aspects of using software but also subjective and emotional aspects. Therefore, WCAG implementation may affect user experience positively (Aizpurua et al., 2016).

Additionally, Power et al. (2018, p. 440) found that "*there was a significant decrease in the mean number of user problems between non-conformant websites and Level A conformant websites*". Both WCAG 1.0 and 2.0 conformant websites received the same results in their evaluations with experience experts. However, they argue that based on their evaluations, the WCAG

upgrade from 1.0 to 2.0 has not had the expected effect on accessibility as there was no significant decrease in the mean number of user problems between the two (Power et al., 2018).

Based on previous work, it can be said that the accessibility of a website can be positively affected by WCAG implementation. Nonetheless, adapting WCAG does not necessarily mean that a digital product or service will be fully accessible. Therefore, existing studies (see e.g. Power et al., 2018; Sato et al., 2010) advise practitioners to include users who would benefit from accessibility in the development process.

2.1.3 Evaluating accessibility

As one of the best known accessibility frameworks, WCAG is often used as the baseline for accessible software. WCAG itself offers success criteria as well as technological suggestions for enhancing accessibility. The guidelines are supported by the Website Accessibility Conformance Evaluation Methodology (WCAG-EM) which can help practitioners to determine accessibility issues (W3C, 2016).

For a comprehensive accessibility evaluation, W3C (2016) suggests a five-step procedure:

- *defining the evaluation scope* by selecting a website for the evaluation, defining the WCAG conformance target and baseline for accessibility support, and listing other possible accessibility requirements;
- *exploring the target website* by identifying common web pages, key functionality and page types of the website as well as used web technologies;
- *selecting a representative sample* from both identified (as described before) and randomly selected web pages and features as well as complete processes performed on the website;
- *auditing the selected sample*, including alternate versions and states of web pages, by using the WCAG success criteria; and
- *reporting the findings* by documenting the outcomes of the previous steps (W3C, 2016).

The extent of the steps may vary depending on several factors, such as age, size and complexity of the website (W3C, 2014). For instance, the sampling

for a small website is likely to include the whole website, or at least most of its web pages (W3C, 2014). WCAG has been criticised for being too context-independent and difficult to understand (Katsanos et al., 2012) which may impact not only the implementation quality but also the ease of accessibility evaluation.

To support digital practitioners, W3C has put together an accessibility evaluation tools list[6] of more than 120 resources. Although many of them use WCAG as the evaluation baseline, the list also contains resources with different focuses and strengths.

Vigo et al. (2013) studied capabilities of automated and semi-automated accessibility evaluation tools. They note that based on previous studies, semi-automated tests can find around 44–50% of accessibility challenges listed in guidelines (Vigo et al., 2013). That would still leave a minimum of 50% of accessibility issues that cannot be detected by tests and require the effort of human evaluators. Moreover, Vigo et al. (2013) conducted their own evaluation of a selection of automated tests and found that only 23–50% of the WCAG 2.0 success criteria, depending on the tool, were covered by those automations. It has been argued that relying on guidelines and tools alone for accessibility evaluation is not enough, and should be combined with other techniques such as user evaluations and expert reviews (Yesilada et al., 2015).

Freire et al. (2007) explored existing work on web accessibility in the form of a systematic literature review. They categorised the papers in their sample into ten groups according to ISO/IEC 2207 processes. Some 31 out of the 53 reviewed articles were classified as studies related to accessibility evaluation. Freire et al. (2007) note that most of those studies are related to guideline-driven evaluations with either manual and automated approaches. Moreover, seven studies they reviewed focus on measuring accessibility of web applications and techniques for interpreting evaluation data (Freire et al., 2007).

Furthermore, there are accessibility metrics that have been constructed as part of academic work. A study (Rodríguez et al., 2017) constructed a framework for evaluating both accessibility and usability of open courseware (OCW) websites based on WCAG-EM. The biggest difference between WCAG-EM and the evaluation system of Rodríguez et al. (2017) is the added usability evaluation during step 4 based on the three ISO 9241 measures

[6]See Web Accessibility Evaluation Tools List by W3C (2016): `https://www.w3.org/WAI/ER/tools/` [Accessed: 31/10/2019].

(efficiency, efficacy, and satisfaction). Additionally, the execution of each of the steps are described in detail using a case study as an example. They found evidence of the viability of their method in OCW environment and, thus, recommend the application of their framework in case of OCW websites (Rodríguez et al., 2017).

Song et al. (2018) bring up that many previous studies related to accessibility metrics emphasise the importance of user experience (UX). Still, according to Song et al. (2018), few of the created and evaluated metrics consider UX as part of them. They propose their Reliability Aware Web Accessibility Experience Metric (RA-WAEM) as a solution to the aforementioned issue. In their study, they compared the performance of different accessibility metrics, including RA-WAEM and five other evaluation metrics, combining accessibility scores and UX satisfaction rates (satisfied percentage). They found that RA-WAEM and its predecessor Web Accessibility Experience Metric (WAEM) significantly outperform the other existing metrics on reflecting the UX. While all the other evaluated metrics rated between 70.38% and 76.55% in satisfied percentage, WAEM and RA-WAEM received scores 85.79% and 86.89% respectively. Thus, RA-WAEM may match accessibility evaluation results and UX of persons with disabilities more reliably (Song et al., 2018).

2.1.4 Legislation

It seems like the accessibility of the digital world was an issue in the 2000s (Lazar et al., 2004; Stephanidis, 2001) and it still continues to pose a challenge in the late 2010s (see e.g. Gonçalves et al., 2018; Wentz et al., 2018). To address accessibility and answer the digital accessibility needs of the world's diverse population, multiple countries have taken action and included digital accessibility to be a part of their legislation over the last two decades (see Appendix A for a collection of legislation around the world).

One of the early actors in the legal field of digital accessibility was the USA with renewed *Section 508 of the Rehabilitation Act*[7]. Although the section has already existed since 1986, it was amended in 1998 to require governmental bodies to ensure their electronic and information technology is accessible for persons with disabilities. The Section 508 compliance is defined through its own web accessibility criteria that has some similarities to WCAG.

[7]Section 508 of the Rehabilitation Act: `https://www.section508.gov/`.

Moreover, there are other American laws that take a stance on digital accessibility. The *Americans with Disabilities Act*[8] (ADA) came into force in 1990 and based on several lawsuits, it has been interpreted to apply to digital products and services provided by both public and private entities. As of 2015, the *Air Carrier Access Act* has been extended to apply to websites and automated ticket machines. However, in the case of both laws, metrics for accessibility evaluation are not specified as leading to challenges in adequate accessibility implementation.

Similarly, laws and regulations regarding accessibility have emerged in Europe. In 2010, the EU launched the *European Disability Strategy 2010–2020* that aims to promote a barrier-free Europe in accordance with the UN Convention on the *Rights of Persons with Disabilities* (UNCRPD) (European Commission, 2010). Some of the key strategic initiatives related to online rights and digital accessibility have been the *Web Accessibility Directive* (WAD) and the *European Accessibility Act* (EAA).

The WAD (2016/2102) applies to websites and mobile applications of public sector bodies (European Union, 2016). The final version of the directive came into effect in 2016 after which each of the EU member states started to prepare their own legislation for it. The accessibility baseline of this directive is European standard EN 301 549 (European Union, 2016) which is based on WCAG 2.1 and its conformance level AA line of this directive is European standard EN 301 549 V2.1.2 (2018). As of September 2019, the most recent public sector websites should be accessible according to the given standard. The transposition period will come to an end in June 2021 after which all public sector websites and mobile applications should be accessible (European Union, 2016).

The EAA (2019/882) sets accessibility requirements for a predefined list of products placed on the market and services provided to consumers after 28 June 2025 (European Union, 2019). After the initial proposal by the European Commission commenced the process in 2015, the directive was adopted by the European Council in April 2019 (European Council, 2019) and, consequently, published in the Official Journal of the EU (European Union, 2019). According to the European Commission (2019), the products and services have been identified with the support of stakeholders and experts as the "*most important for persons with disabilities while being most likely to have diverging accessibility requirements across EU countries*". The selected products and services are as follows (European Union, 2019):

[8]Americans with Disabilities Act: `https://www.ada.gov/`.

- Computer hardware and operating systems;
- Self-service terminals such as cash points and payment terminals as well as ticketing and check-in machines;
- Smartphones, tablets and e-readers for electronic communications services and accessing audio-visual media services and e-books;
- TV equipment related to digital television services;
- Telephony services and related equipment;
- Audio-visual media services;
- Services related to passenger transport;
- Banking services;
- E-books and related software;
- E-commerce services (European Union, 2019).

The list includes both digital UIs and physical products. However, instead of using the aforementioned European standard as the base for digital accessibility, the implementation guidelines have been redesigned. Still, it is highlighted that the four principles of accessibility (perceivable, operable, understandable, robust) are relevant for the EAA, creating a connection between the two directives. Point c in Section III of Annex I (*Accessibility requirements for products and services*) of the EAA directive defines the accessibility regulations in the context of websites and mobile device-based services as follows (European Union, 2019):

> "*[M]aking websites, including the related online applications, and mobile device-based services, including mobile applications, accessible in a consistent and adequate way by making them perceivable, operable, understandable and robust*" (European Union, 2019)

This indicates that websites and mobile applications may not be required to be WCAG conformant but they still need to achieve a similar level of accessibility. The description is accompanied by a list of examples on what should be considered to conform to the EAA regulations. Additionally, Section VII of Annex I lists functional performance criteria (e.g. usage without vision or perception of colour or with limited cognition) to support maximising usage by persons with disabilities.

Legislation and lawsuits have also been examined by researchers. Wentz et al. (2018) note that the increasing legal activity acts as a rationale for research

related to accessibility. They also mention that there have been several lawsuits in the financial and banking industry due to lack of accessibility (Wentz et al., 2018). Similar movements have also been reported elsewhere, for example in the governmental sector and educational institutes (Olalere and Lazar, 2011) as well as in retailing services (De Andrés et al., 2010). It has been argued that progress on accessibility has been made partially because of the inspiration provided by accessibility-related lawsuits (Yan and Ramachandran, 2019). However, according to Richards et al. (2012), earlier research has found little evidence on government accessibility regulations having an impact on the state of accessibility.

2.1.5 Accessibility of digital products and services

During the last decade, digital accessibility has become a recurring topic in user-centred design related forums[9] and online articles[10] in addition to being an increasingly researched subject. The rationale for research often comes from increased legal activities, combined with the impact that inaccessibility causes for people with disabilities (Gonçalves et al., 2013; Vigo et al., 2013; Wentz et al., 2018). Next, the states of the current academic literature and digital accessibility are discussed.

Digital accessibility in academic literature

Digital accessibility as a topic has been ascending since the growth of digitalisation started to accelerate. Freire et al. (2007) conducted a systematic literature review on techniques for web development considering accessibility. Out of their initial set of 396 studies related to web accessibility (published between 1998 and 2006), they selected 53 papers for their review for their focus on web development techniques for accessibility. The papers were distributed unevenly over the time frame – only 12 studies had been published between 1998 and 2003, and the rest of them (41) between 2004 and 2006 (Freire et al., 2007). Moreover, Vigo et al. (2013, p. 2) mention "*one of the earliest articles to explore multiple methods*" of accessibility evaluation

[9]See e.g. Joint Futures 2019 conference topics: `https://jointfuturesconf.com/schedule.html` [Accessed: 04/09/2019].

[10]See e.g. accessibility-related articles on Medium: `https://medium.com/topic/accessibility` [Accessed: 22/10/2019].

which was published in 2005. These remarks indicate that academic interest in accessibility may have started to increase around the mid-2000s.

The literature review of this thesis has given a glimpse into the current state of accessibility research. One of the most common angles to researching accessibility seems to be accessibility evaluations carried out either normatively (following WCAG) or inductively (with persons with disabilities or other experience experts). The context of an accessible or inaccessible website or software seems to be of interest, and some of the common surroundings include educational contexts such as school or university websites or educational web services, public or governmental services, or e-health.

The involvement of people in recent evaluations is especially visible. Significant numbers of studies involve blind or otherwise visually impaired persons, dyslexic or cognitively challenged people, and older adults. Moreover, there are studies that take a more general approach and do not select a single disability for their study. Instead, they look at accessibility more holistically but still mainly from the perspective of persons with disabilities or elderly people. It appears that there is also accessibility work related to hearing impairments, motoric challenges and illiteracy, but then neither are those viewpoints as common in the sample of this study.

Freire et al. (2007) have similar findings in their literature review. They find that one of the major web accessibility topics "*is related to user tests and experimental derivation of guidelines*" (Freire et al., 2007, p. 166). Additionally, many of the studies they considered involved blind or low-vision people or persons with other disabilities. Another recurring user group in those studies was that of elderly people (Freire et al., 2007).

It appears that the state of accessibility is regularly studied through evaluating a digital product or service in a selected context of use. One of the most common metrics for measuring accessibility is through the success criteria of WCAG (see e.g. Vigo et al., 2013). Another way to measure accessibility realisation is through user testing sessions with experts by experience (Carvalho et al., 2018; Gonçalves et al., 2018)). Different evaluation approaches and metrics used in the papers that were either fully or partially selected for accessibility evaluation focus are listed in Table 2.

Research papers	Evaluation approach				Evaluation metrics	
	Experience expert evaluations	Non-disabled volunteer evaluations	Expert evaluations	Tool-based evaluations	Inductive findings	Normative findings
Carvalho et al. (2018)	x				x	
Giraud et al. (2018)	x				x	
Gonçalves et al. (2018)	x		(x)	x	x	x
Gonçalves et al. (2013)				x		x
Leitner et al. (2016)			x	x		x
Olalere and Lazar (2011)	x			x	x	x
Power et al. (2018)	x			x	x	x
Rodríguez et al. (2017)		x		x		x
Song et al. (2018)	x	x	x	x	x	x
Vigo et al. (2013)			x	x		x
Wentz et al. (2018)	(x)		x			x
Yan and Ramachandran (2019)				x		x

Table 2: List of academic papers in which the state of accessibility is evaluated either as a primary or secondary focus, and their evaluation approach and accessibility metrics.

Digital accessibility in academic literature

Throughout the Internet era, both the use of the Web and the number of websites and online services have grown rapidly. According to Katsanos et al. (2012), several studies from the early 2000s imply that there were fundamental accessibility issues in at least 70% of evaluated websites. In this study, the current state of accessibility and its potential development over the years is of interest. Thus, a glance at the recent academic accessibility evaluation results is provided below.

Leitner et al. (2016) conducted a WCAG-based accessibility evaluation to 89 private sector websites automatically, supported by manual test rounds if automated tests were passed. Only 12% of the websites passed their evaluation, underlining the low state of accessibility (Leitner et al., 2016). The most common accessibility issues are HTML markup mistakes, encompassing more than 70% of the found problems in all sectors of the study (Leitner et al., 2016).

Vigo et al. (2013) ran an accessibility evaluation on three websites, combining both automated test tools and expert evaluations. Their aim was to benchmark existing automated test tools to find our about their competence in finding issues listed in WCAG 2.0. Altogether 117–433 success criteria violations were found on each website, and the violations were found to be spread across all conformance levels. This implies a weak level of accessibility in the case of each of the three evaluated websites (Vigo et al., 2013).

Gonçalves et al. (2018) ran usability tests that were performed by 20 blind participants on an e-commerce platform, and supported by initial expert accessibility and heuristic evaluations. According to the accessibility evaluation, 13 out of the 61 WCAG 2.0 success criteria across all conformance levels were broken. After completing their tasks on the website, the users answered a satisfaction questionnaire. 75% of the participants "*were not excited to work with [the] site and 60% said they would not want to use [the] site frequently*" (Gonçalves et al., 2018, p. 580). The researchers learnt that none of the participants found the website excellent or great, whilst 15% (three persons) found the website to be good to use. However, the rest of the users had a negative experience – 40% of the users experienced the e-commerce website to be only reasonable to use, and 45% thought the website was of weak quality (Gonçalves et al., 2018).

Moreover, Wentz et al. (2018) studied the accessibility of 100 bank and

finance websites from the USA through automated and expert evaluations. The most prevalent violations of the WCAG 2.0 success criteria included use of non-text alternatives, enlarging the font size, "skip navigation" links to bypass repeating content, and valid HTML markup. Based on their results, Wentz et al. (2018) concluded that US banks and other financial institutions should make accessibility implementation a priority (Wentz et al., 2018).

In the 2010s, mobile devices have become one of the most common means to interact with the Internet since their evolution to smart devices. Carvalho et al. (2018) looked into usability and accessibility issues in mobile devices encountered by six blind and four mainstream users. Their evaluation indicates that although both their visually impaired and normal-vision users encountered problems, the former faced clearly more of them (409 and 105, respectively) (Carvalho et al., 2018). The blind users were also more severely impacted by the identified issues which is visible through their low task success rate (Carvalho et al., 2018). Similarly, Yan and Ramachandran (2019) found widespread accessibility conformance issues in the 479 Android mobile applications they evaluated.

Other recent studies showcase similar results in their accessibility evaluations (Olalere and Lazar, 2011; Power et al., 2018; Rodríguez et al., 2017). This hints that although the use of the Web and the number of websites have grown exponentially, the state of accessibility on websites and applications has not matured accordingly. Vollenwyder et al. (2019) note that despite guidelines and their incorporation into legislation, web accessibility often remains dissatisfactory. Interestingly, a study (De Andrés et al., 2010) also indicates that European companies have a lower level of web accessibility that their US-based counterparts and argues that it may be due to accessibility-related lawsuits being more common in the USA.

2.2 Agile software development

One of the most common software development methodologies in the 2010s has been agile methodology. The core of agile is its ideology which values flexibility, efficiency and communication. In this subchapter, *agile software development* is defined and some of the most common agile processes and practices are introduced. Then, the intersection of agile software development with user-centred design as well as accessibility implementation are discussed.

2.2.1 On the definition of agile software development

The software engineering field underwent a revolution in the 2000s after the Agile Manifesto[11] was published (Dingsøyr et al., 2012) by a group called the Agile Alliance in 2001, changing the way software development was viewed over the next two decades. It inspired practitioners to introduce new methods, tools and best practices (Dingsøyr et al., 2012). Often, agile methods are seen as a family of methods under the Agile Alliance such as Scrum and eXtreme Programming (Wang et al., 2012) but as of today, many additional methods and approaches have emerged.

Dingsøyr et al. (2012) consider that there were some new movements that summarise the agile transformation in the 2000s: rise of collaborative development; "lean", or efficient and optimised mentality; active participation of stakeholders in the development process; and acceptance of uncertainty. Additionally, Wang et al. (2012) highlight the importance of iterative life cycles as a way to react to change, and constant learning aspect. It is also common to establish a *definition of done* to estimate "*when a user story is considered to be implemented*" (Nikitina et al., 2012, p. 146).

Agility can be defined through the ultimate purpose of being agile – an organisation's ability to react to changes in its environment at a faster rate than those changes arise (Kruchten, 2013). Thus, any team or organisation with this ideology in their mind can be called agile. There are also agile practices and ways of working, such as Scrum or Kanban, that can be followed to support agile aspirations.

In this study, the term *agile* refers to an ideology where active collaboration and communication as well as lean, reactive and iterative mentality have a central role in software development. It can also be used to describe the nature of teams, organisations, project management or software development in general. As the context of this study is within *agile software development*, all the software development-related content discussed in this thesis has agility and often agile processes and methods behind it.

[11] Agile Manifesto: `https://agilemanifesto.org/` [Accessed: 4/11/2019].

2.2.2 Agile software methods and processes

Several agile processes started to gain ground in software development after the forthcoming of the Agile Manifesto. It appears Scrum was one of the most researched agile methodologies in the 2000s (Dingsøyr et al., 2012) while Kanban in software development context was quite a recent approach in early 2010s (Nikitina et al., 2012; Wang et al., 2012). They are both described as lightweight agile methods that involve a high level of collaboration, aspiration for self organisation and a lean mindset (Kniberg and Skarin, 2010).

According to Kruchten (2013), one of the most important factors for software process is the context, and there are two levels of context that should be considered. The first level of context is the organisational level that defines the environment for software development. The organisational factors include the business domain of the company, number of instances to be developed, software maturity of an organisation, level of innovation, and cultural context of the project. The second level is the project-level context, and it consists of several attributes such as the size of the system, business model, team and team member distribution and project management system (Kruchten, 2013).

The *Scrum* approach is a method for managing the development process. The main focus is on team members and how they can function flexibly and productively in a constantly changing environment. As there are several environmental and technical variables that may change unpredictably even in a short period of time, the development process requires flexibility of the team. (Abrahamsson et al., 2002)

In a typical Scrum process, requests are put into a backlog. The project managers take the roles of a Product Owner (PO) and Scrum master. The PO is in charge of the backlog priority order. Both development and testing proceed in Sprints, timeboxed project iterations. Each Sprint starts with the PO choosing a number of items from the backlog for the Sprint, which are then estimated by developers and testers to ensure a reasonable number of requests. The tasks are performed during the iteration, after which the Sprint is closed with a Sprint review meeting and finished requests are delivered. (Anderson et al., 2012)

In some methods, lean ideologies are applied more heavily in agile software development. The main objective of *Kanban* is to minimise the amount of work-in-progress tasks (the number of items that a team works on (simulta-

neously) and with that, maximise the produced value by keeping the process flowing evenly (Anderson et al., 2012; Wang et al., 2012). This idea of minimising "waste" is typical of Lean approaches, and it can lead to a team's increased ability to perform their work especially if the team is dealing with maintenance work (Anderson et al., 2012). One of the strengths of Kanban is that the workflow is visualised at all times (Kniberg and Skarin, 2010) making the entire process it easy to follow. Additionally, there are no defined meetings such as daily standups, demonstration sessions or retrospectives (Kniberg and Skarin, 2010).

In Kanban approach, all feature requests are placed in an input backlog with no estimations. Business owners manage the backlog and decide which backlog items are placed in the input queue. Both the number of items under work and length of the input queue are limited at any given time, ensuring that developers are able to focus on single requests. Finished requests gain a "done" status which can then be tested by testers and delivered at the end of the cycle. (Anderson et al., 2012)

Based on the previous descriptions, it can be said that there are several similar features between Scrum and Kanban. These similarities also allow for combining the two methods into one approach called *Scrumban* (Banijamali et al., 2017; Nikitina et al., 2012). Banijamali et al. (2017) argue that as Scrumban combines the best features of both approaches, it may as well override Scrum and Kanban in the future. The mixture of iterative planning and high change responsiveness may allow even more flexibility to a project that Scrum or Kanban can separately allow (Banijamali et al., 2017). Thus, Scrumban is seen to be well suited for projects with unexpected user stories (Wang et al., 2012).

2.2.3 User-centred design in agile projects

Digitalisation has increased the role of software in people's lives. Due to the oversupply of digital products and services, users can easily pick one that suits their needs or pleases them the most. As a result, user-centred design (UCD) and good user experience (UX) are important not only for the sake of users but also for the success of software engineering organisations. Thus, it has been argued that not only agile mentality but also UCD have characterised the transformation of the software development field (Brhel et al., 2015). Next, the role of UCD in agile context and a usability model for user-centric work are discussed.

Combining usability and agility

Sohaib and Khan (2010) conducted a literature review on usability engineering and agile software development. Their aim was to learn whether usability fits well with agile mentality and processes. Based on their review, Sohaib and Khan (2010, p. 37) conclude that UCD can be adapted in agile context for example by "*incorporating user scenarios and including usability specialists in the team*". Although there are some contradictions such as agile development often favouring quick start of the actual development and the UCD perspective preferring to first gather all the important pieces from the users' viewpoint, Sohaib and Khan (2010) still argue that usability and agility are well compatible (Sohaib and Khan, 2010).

The close proximity of UCD and agile software development has brought upon hybrid development models that pursue to combine them both. Brhel et al. (2015) studied this phenomenon through a systematic literature review between the years 2002 and 2012, and attempted to find principles that are common in the aforementioned hybrid models. It appears that the interest in the integration of UCD and agile software development started gaining momentum in 2007 after which the number of relevant articles published every year has been higher and higher (Brhel et al., 2015).

Brhel et al. (2015) learnt that there seems to be a growing interest in the social dimension of user-centred agile software development (UCASD). They were able to identify five principles that hybrid development models and projects shared. (i) First, they argue that UCASD should have separate product discovery and product creation phases. In addition, both design and development should be implemented (ii) in short iterations and increments and (iii) in parallel tracks that are connected to each other. (iv) Stakeholders should also be actively involved in the project, preferably throughout the entire process for continuous dialogue. (v) Finally, tangible artefacts should be used to both communicate product and design concepts with stakeholders as well as document the process. Although Brhel et al. (2015) were able to identify the aforementioned principles, they found that it was challenging to form stable principles for applying UCD and agile in practice due to the gaps in empirical evidence (Brhel et al., 2015).

Usability model

In accordance with previous research (Brhel et al., 2015), ISO also suggests an iterative design approach in *Part 210: Human-centred design for interactive systems* of Standard 9241 (ISO, 2019). In the beginning, it is essential to plan the human-centred design (HCD) process in order to establish its position as a part of a development project (ISO, 2019). After the plan has been constructed and the need for implementing a product or service has been identified, the design process itself can begin (ISO, 2019). HCD activities during the development process can be summarised in four core steps:

- Understanding and specifying the context of use;
- Specifying the user requirements;
- Producing design solutions, or an artefact; and
- Evaluating the design (ISO, 2019, p. 10).

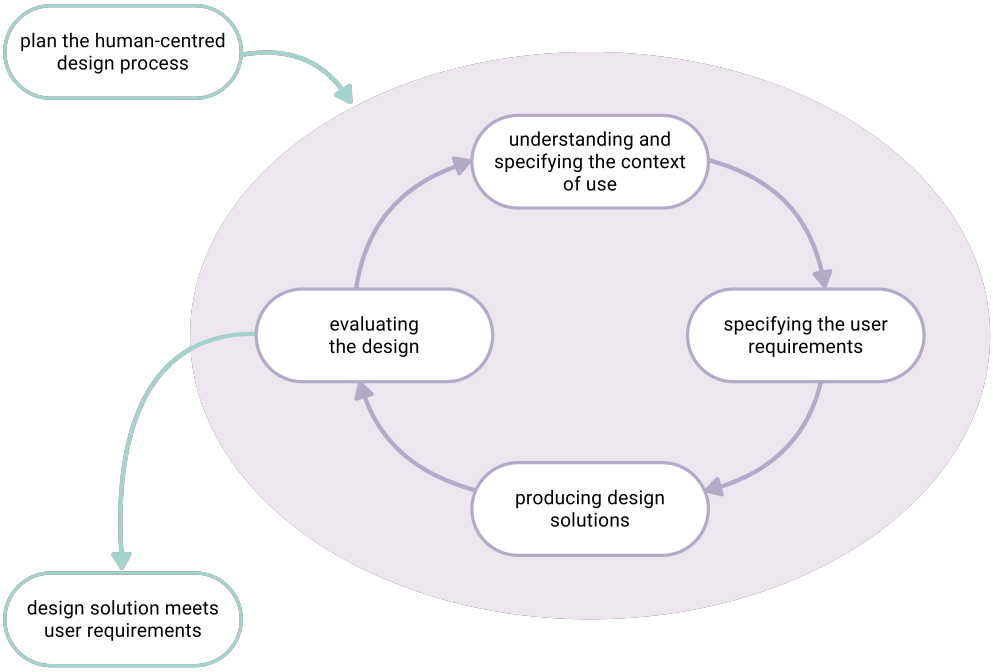

Figure 3: Human-centred design process from planning to finished solution (adapted from ISO, 2019, p. 12).

The steps form an iterative cycle that is repeated until the designed product or service meets user requirements. The process can be started from any of the steps as it depends on the project which is the best step to start with. Figure 3 visualises the iterative cycle of HCD activities and their interdependence.

The first version of the model was published in the 1999 version of the ISO standard 13407. However, it was revised by 9241-210 in 2010, followed by the updated version in 2019. It has also been referred to in academic literature (Sohaib and Khan, 2010).

2.2.4 Accessibility in software development

According to a study (Leitner et al., 2016), more than 70% of the encountered accessibility issues are technology-related. Most of the aforementioned problems are HTML markup mistakes (Leitner et al., 2016). Leitner et al. (2016) argue that this may be due to the high error tolerance of modern graphical browsers and their automatic rendering repairs. Wentz et al. (2018) listed the top five violated WCAG 2.0 success criteria in their sample. They also learnt that valid HTML markup was one of the most common violations (Wentz et al., 2018). Other technology-related violations were the ability to resize text without assistive technology, mechanisms to bypass repeatable content blocks, and missing alternative texts for non-text content (Wentz et al., 2018). These findings indicate that it would be important to focus on accessibility in more detail already during software development to be able to make an impact.

Stephanidis (2001) emphasises that accessibility should be considered from the early design stages instead of being an afterthought in the implementation cycle of a software. One possible approach could be the "reactive" approach where accessibility needs and challenges are turned into user requirements and used to avoid known issues. However, it might become problematic if those needs and the solutions for them are not evaluated, especially with continuous technological changes that lead to new generations of accessibility problems. Therefore, Stephanidis (2001) suggests that the broadest possible end-user population should be taken into account interactively early on during the design of a new product or service (Stephanidis, 2001).

As discussed earlier in Section 2.1.1, accessibility is commonly studied together with usability or UX, and a correlation between them have been found

as well. Therefore, it would be valuable to teach accessibility alongside HCI and UCD and not as an isolated topic (Yesilada et al., 2015) and, thus, tie accessibility more strongly together with HCI. This could also help practitioners see that accessibility should not be a separate process but an inseparable part of UCD.

Practitioners also seem to associate usability and accessibility with one another. Yesilada et al. (2015) asked how people with an interest in web accessibility experience the relationship between accessibility and usability. The respondents agreed that accessibility and usability are highly related (Yesilada et al., 2015). Moreover, Aizpurua et al. (2016) explored the relationship between accessibility and usability and found a connection between the two which correlates with the experiences mentioned before.

2.3 Organisational factors

Digital practitioners often work within a team and an organisation to gain a wide selection of professional skills around them. In that case, a single practitioner or team is usually not completely independent from the rest of the organisation. Thus, although an individual team can take action towards accessibility, new practices or change in general, the support of the organisation is required in the long run. Although there is previous research on digital accessibility in general, there seems to be little work on improving accessibility from the business or organisational perspective. Freire et al. (2007) discovered no work on accessibility implementation processes within project teams and organisations in their systematic literature review. Moreover, Leitner et al. (2016) note that web accessibility has gained little attention within business administration or management science.

Next, organisational factors related to accessibility are discussed. *Organisational change* is explored through some of the pioneering theories and case studies, after which *design system* and its place in a software organisation are described. Then, some widely used *maturity and quality control models* in software and service design as well as HCI are introduced. Finally, the possibilities, challenges and other factors regarding accessibility implementation in an organisational context are discussed.

2.3.1 Change in an organisation

There are several reasons why an organisation might be willing to pursue change. It might enhance operational processes, create a more positive image, or even bring potential business value. However, it is of interest how change can be achieved successfully and what the potential obstacles are in the process. Next, organisational change is explored through existing theories and case studies.

Organisational change theories

Kurt Lewin was a psychologist in the early 1900s who is known for his research and theories of planned change, applied behavioural science and action research (Burnes, 2004). According to a study (Burnes, 2004), Lewin's work has been criticised by many to be redundant and outdated due to too linear, static and simplistic approach. However, Burnes (2004) argues that Lewin's models and theories on planned change are not at all outdated but may have been analysed superficially and misunderstood due to misreading Lewin's perceptions on change and stability. His theories have also been used as material for modern studies on organisational change (see e.g. Adams and McNicholas, 2007; Nelson, 2003).

The main elements of Lewin's Planned approach to change include Field theory (understanding the complexity of the field and group), Group dynamics (group behaviour should be the main focus of change), Action research (change requires action based the initial situation), and the 3-step model (stabilising the state of change at the end) (Burnes, 2004). One of Lewin's key thoughts regarding behavioural change was that although change is usually a slow process, quick and radical shifts are possible for example in case of a personal, organisational or societal crisis. In addition, there should be an inner understanding that change is essential – otherwise introducing change in a group or organisation may become problematic. Nevertheless, Lewin had experienced that after a crisis has been bypassed, it is easy to return to the old habits instead of achieving permanency at the new level. This is what led Lewin to develop the 3-step model of change (Burnes, 2004).

The 3-step model is a simplified change model that summarises the different states of a change process into three parts. The first step (*unfreezing*) concentrates on destabilising the existing balance to create a base for adopting new behaviour (Burnes, 2004). At this point, different motivations may drive an

organisation understand that they are in need of change. During the second step (*moving*), all the possible options for action are identified and evaluated through trial and error, and change is taken forward (Burnes, 2004). Finally, the third step (*refreezing*) aims to ensure that the newly learnt and accustomed habits are truly established in ways of working (Burnes, 2004).

There are also newer approaches to change that have made their way to organisations. For example, a model for successful business process change was introduced in the 1990s (Burn and Robins, 2003). The core idea of the model is that a significant business process change requires a vision of change that is well defined and communicated by the leaders of the initiative, and an organisational culture with a willingness to learn and share knowledge (Burn and Robins, 2003).

Nelson (2003) also studies on the overall aspect of change based on her case study and existing theories. She states: "*It is not difficult to find examples in history of intentions and plans becoming bogged-down due to an inability to embrace flexibility*" (Nelson, 2003, p. 24). She argues that change is not a single event or activity but a series of events and activities that require flexibility from an organisation. The events unfold progressively, and each of them impacts the organisation and the overall process, making change a dynamic process. Nelson (2003) highlights that the progress should be monitored and feedback should be acted upon to support the change process (Nelson, 2003).

Case studies on change

Theories about organisational change may help to understand technicalities about a change process. However, real life cases can shed light into actual change processes and experiences in a completely different way. Case study findings can also be potentially applied to change design.

Burn and Robins (2003) looked into an e-government strategy project in an organisation where the prior digital presence had been minimal. The actions taken to create desired change in the organisation were related to active involvement of business, clear leadership and ownership of the process change, knowledge increasing and sharing, communication and cooperation as well as setting clear goals and planning how to get there. However, there was no formality in the process of change. According to Burn and Robins (2003), the project was successful in achieving its goals. They identified

the key factors of success to be "*the need for a project champion, the need for senior executive support and a requirement to involve all sections of the organisation*" (Burn and Robins, 2003, p. 34).

Adams and McNicholas (2007) studied how creating a sustainability report and developing a process for it can promote organisational change regarding sustainability performance. The company was motivated to develop by a will to become a more sustainable company, and an interest to gain recognition. The change process was driven by inspired leaders, active managers, promotion of sustainability reporting in the industry and the competition from other companies in the same industry. Adams and McNicholas (2007) observed that the key impediments were the lack of experience (engaging stakeholders, identifying key performance indicators, choosing what to do out of many options) and lack of knowledge (best practices, integrating ways of working into the organisation strategy, differences between financial and economic indicators) in the sustainability reporting process in addition to the lack of resources such as time Adams and McNicholas (2007).

Nelson (2003) aimed to learn how an electricity company was trying to achieve commercialisation. One of the key lessons learnt was that change in an organisation is a complex process. There were several reasons why the case company faced challenges in their process. There was a lack of strong leadership and coherent strategy which led to meandering and extended negotiations. Additionally, there was no competition in the field that would have created an urgency for change. Although management invested in an extensive communication programme, it was mainly about changes to come instead of letting the employees know about the reasons behind change. Moreover, there was little information about the future of employees and even some half-truths that created an atmosphere of uncertainty. Finally, the management was unable to provide the employees with a new, common vision that could have inspired the employees in the process (Nelson, 2003).

Nikitina et al. (2012) investigated how transitioning from one agile method (Scrum) to another (Scrumban) happens in a software development organisation. The process was divided into three parts: pre-transition investigation, actual process transition, and post-transition assessment. During the first phase, process-related problems were identified and change was initiated through communicating the need for change, setting up a role of transition manager, and training team members to understand both the reasons for transition and the new process. The second part consisted of training session and process assessment iterations that drove the change. This included

new ways of working as a team such as new patterns for meetings, communication and the development cycle. Finally, the third phase was an iterative phase that centred around iterating the process through bi-weekly assessment meetings. Towards the end of the study, the initial problems were revisited and found to be either partially or fully solved in most cases (Nikitina et al., 2012). This suggests that the transition did not only happen successfully but it also helped to solve earlier issues.

The case studies described above were selected for this thesis because of the nature of the change they were trying to create. Burn and Robins (2003) had their focus on digital transformation of an Australian governmental body; Adams and McNicholas (2007) looked into an ethical and ecological change in a corporate environment; Nelson (2003) learnt about creating an organisation-wide change while only the top management was onboard; and Nikitina et al. (2012) studied a transition of software development processes. Although driven change and goal were different in each of the aforementioned case studies, they all show overlapping themes. This indicates the significance of these themes in organisational change, especially in technology and responsibility related topics.

Conclusions on organisational change processes

Based on the theories and case studies introduced earlier it can be said that there seem to be certain things that change processes share. The process starts with at least one **motivator** that drives an organisation to consider the need for change. Once the intent is strong enough, the organisation may start preparing for an **action** which often turns into multiple steps and **iterations** to find the best ways to facilitate the development. However, knowledge and resources regarding the change are required to **enable** the process.

Depending on the pursued change and its nature, there might not be an actual end to the process. Still, if the new thoughts behind the change have been widely accepted in the organisation and incorporated into work, it could be said that the change has been accomplished to some extent. Motivation and other influences may come from inside the organisation or outside of it, connecting the organisation into the society around it.

2.3.2 Shared design system

It appears design systems have become a part of the digital design world in the 2010s (see e.g. Abcarians, 2014; Beck, 2017; Hacq, 2018). As of today, some design companies have constructed their own guidelines for creating a design system based on experience in the industry (see e.g. Design Systems Handbook by Suarez et al., 2017). Moreover, several companies have decided to share their design systems and pattern libraries[12] online for anyone to reference or draw inspiration from.

The foundation of design systems is in systems thinking (Suarez et al., 2017) in which it is believed that phenomena are emergent properties of a whole (Flood, 2010). Similarly, a design system can be described as a collection of design elements, components and conventions (Abcarians, 2014; Hacq, 2018) that can be easily scaled and applied to product or service needs (Hacq, 2018; Suarez et al., 2017). A design system can be scaled not only to a singular ever growing product but also to several products and teams that have a reason to share the same design language[13]. In addition to scalability, it has been argued that a design system may support design teams in designing consistently and improving accessibility of their products (Suarez et al., 2017).

However, it seems that currently most material about design systems is industrial rather than academic due to its novelty. Therefore, there is little academic knowledge about best practices and processes regarding design systems.

2.3.3 Maturity models and quality control in product and service business

By tracking process maturity and product quality, organisations can know more about their capabilities. This may also support organisations in developing their future aspirations. Next, different maturity models and aspects of quality control are presented.

[12]See e.g. IBM Design Language: `https://www.ibm.com/design/language/` [Accessed: 18/11/2019].

[13]See e.g. Material Design by Google: `https://material.io/design/` [Accessed: 12/6/2019].

Maturity models

It is valuable for any organisation to determine its process maturity as it can help with both business stability and improving it. Maturity models can be used as a tool to evaluate the maturity of an organisation and help plan for improvement. There are several different maturity models that one can choose from depending on the organisation as well as the desired development and change. (Albliwi et al., 2014)

The Capability Maturity Model for Software (CMM) is one of the most common maturity models for measuring processes and overall maturity of an organisation (Albliwi et al., 2014). The CMM consists of five maturity levels (Figure 4), and the traits of projects and the organisation on each level are described in detail in the CMM documentation (Paulk et al., 1993). Its development originally began in 1986 with the aim of creating a process that would help organisations improve their software processes (Paulk et al., 1993).

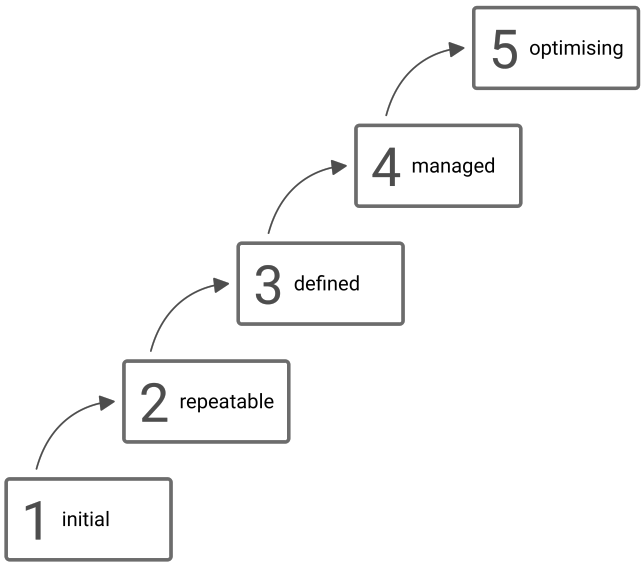

Figure 4: Capability Maturity Model (CMM) organised into five levels of software process maturity (adapted from Paulk et al., 1993, p. 8).

The first level is the *initial* level during which software processes may be impulsive and less defined. Therefore, it can be difficult to predict outcome or learn from experience. During the second level, the basic project manage-

ment processes have started to become *repeatable* and become an ordinary part of at least some software teams. At the next level, the *defined* level, both management and engineering activities have been standardised and documented within the organisation, and teams apply those processes to their projects. At the last two levels, deeper analysis and measurement of practices comes to the forefront. An organisation at the fourth, *managed*, level aims to measure its software processes to understand and control them. Finally, at the fifth level, the *optimising* level, the organisation consciously works to continuously improve their software processes. (Paulk et al., 1993)

The CMM is based on software process assessments and extensive feedback from both industry and government (Paulk et al., 1993). After the first published version of the model, it has also been developed based on both reviews and feedback after use by the software community as well as workshop outcomes with software professionals (Paulk et al., 1993), increasing its validity. However, there has been criticism that most maturity models rely on levels leading towards a predefined "end state" instead of focusing on the factors that actually influence evolution and change in an organisation (Röglinger et al., 2012). In addition, the CMM has been criticised for being confusing to use due to different structures, terms and formats that it may come in (Albliwi et al., 2014). Although the CMM itself has been iterated and updated, there are also independent versions such as Capability Maturity Model Integration (CMMI) and CMMI for Services that share many similarities with the CMM (Albliwi et al., 2014).

There are also other specialised maturity models that have different focuses. Earthy has introduced the *Usability Maturity Model* (UMM) (Earthy, 1999) and its companion, the *Human-Centredness Scale* (HCS) (Earthy, 1998) as tools to analyse the level of usability maturity of an organisation. Both frameworks are organised in six levels that start from incomplete or unrecognised levels. The focus of the HCS is on assessing organisational attitudes to human-centred approaches (Earthy, 1998) whereas the UMM concentrates on measuring the usability process performance (Earthy, 1999).

According to Earthy (1999), the six levels of the UMM are:

0. *Incomplete* – organisation is not able to perform human-centred design (HCD) processes at all;
1. *Performed* – individuals at the organisations are able to carry out HCD processes;

2. *Managed* – processes have already become known at the organisational level and quality, time and resource requirements are controlled to some extent;
3. *Established* – HCD processes have been specified and resources have been defined by the organisation;
4. *Predictable* – performance of processes is somewhat predictable regarding resources and set quality frame; and
5. *Optimising* – the organisation is confident enough with HCD processes that it is able to tailor the process according to particular needs for example regarding a project (Earthy, 1999).

The six levels of the HCS by Earthy (1998) build on each other. The levels are:

0. *Unrecognised* – no indications of usability considerations;
1. *Recognised* – some usability issues are recognised and acted upon whilst teams may be actively hostile to users;
2. *Considered* – there is an awareness that systems are made for users;
3. *Implemented* – there is a user focus and understanding that end users need to be consulted;
4. *Integrated* – human-centred processes and user involvement have become a routine; and
5. *Institutionalised* – the cultural and business focus is on users (Earthy, 1998).

As can be seen, the UMM is relatively similar to the CMM, moving from chaotic implementation and consideration to a state where the development has been internalised in organisational processes. Interestingly, although the final state is also similar at the HCS, the focus is solely on attitude and experienced importance of usability and users. This increases the depth of the model, making it applicable to problems that may have an emotional aspect to them.

Quality control

Iterative and cyclic processes have been introduced to product management and design since before an agile approach arose in software development (Taylor et al., 2014). The idea of the quality improvement methodology

Plan-Do-Check-Act (PDCA) originates from 1939 when the Shewhart cycle (specification-production-inspection) was introduced (Moen and Norman, 2009). It was followed by the enhanced Deming wheel in 1950 that had an extra step and sales focus on it: design, production, test during sales, and redesign (Moen and Norman, 2009).

The Deming wheel was adapted to create the PDCA cycle (Figure 5) in 1951. The first step, planning, consists of pre-production planning and designing. The second part, do, is the part when the product is actually made. During the check phase, customer satisfaction is tested through sales. Finally, action is taken if a complaint about the product is filed, and the found issue is incorporated into the next planning phase. (Moen and Norman, 2009)

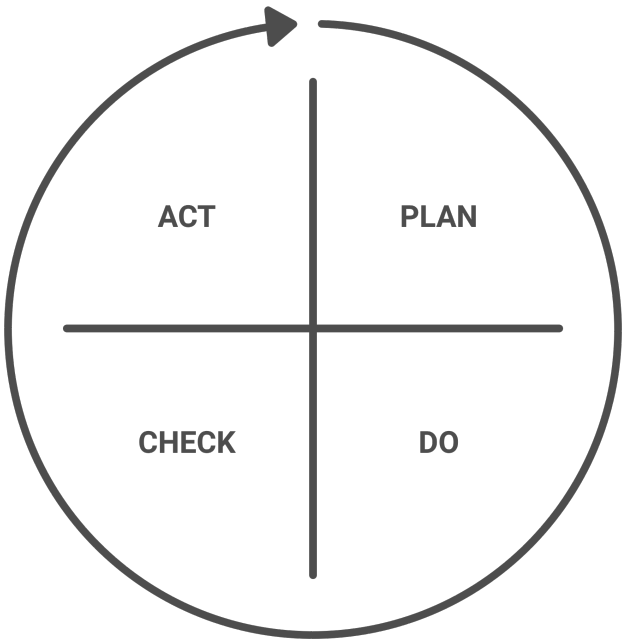

Figure 5: The Plan-Do-Check-Action cycle for product design (adapted from Moen and Norman, 2009, p. 7).

Another iteration of the PDCA from the 1990s is called the PDSA (plan-do-study-act) cycle in which the step check has been changed into study. The focus of the PDSA is to test and observe, preferably on a small scale, whether an idea would have a positive impact on a product or service. Based on the results, it is decided whether the change is adopted or not. (Moen and Norman, 2009)

As of today, PDCA and PDSA cycles and their derivatives have been successfully applied to several fields to improve the quality of products, services and processes. These fields include for example healthcare(Taylor et al., 2014), education (Ćukušić et al., 2010), and water supply management (Bereskie et al., 2017). This implicates that iterative quality improvement tactiques may have a positive impact on product and service quality regardless of the industry.

2.3.4 Factors and possibilities related to accessibility implementation

Based on previous work, it can be assumed that the overall state of web accessibility is still poor in the 2010s. This has encouraged researchers to investigate the reasons that lead to continuous inaccessibility and, in those rare cases, to accessibility. Next, accessibility implementation-related factors and possibilities are discussed.

Accessibility-related beliefs and attitudes

Vollenwyder et al. (2019) studied how accessibility-related beliefs influence practitioners' intention to consider accessibility in their work. They ran an online questionnaire and received 342 answers for their study from professionals in different roles. Vollenwyder et al. (2019) used the Theory of Planned Behaviour (TPB) as the theoretical base and findings from a systematic literature review as the empirical base for their questionnaire.

They found that the main beneficial salient beliefs were *user advocacy*, *self-perception as a specialist*, and *product quality*. The beneficial beliefs also seemed to have a higher positive impact than the main hindering salient beliefs *requirements conflict* and *personal effort*. According to the study, if users actively demand accessibility, it can reduce misunderstandings regarding persons with disabilities, such as them not using the web. Self-perception as a specialist can provide a strong motivation to confront challenges, including accessibility issues. Moreover, positioning accessibility as a product quality matter may inspire practitioners in their work. (Vollenwyder et al., 2019)

In addition, Yesilada et al. (2015) asked questions about accessibility and inclusion from over 300 people with an interest in accessibility (87% of them

being technical practitioners) in the form of a questionnaire. They learnt that their respondents experience that accessibility is applicable to every possible user and not just for persons with disabilities. The respondents also indicated that accessibility should be grounded in user-centred practices. Finally, they perceived that accessibility evaluation should not only concentrate on source code inspection; rather, including users in the process was considered beneficial even though user testing was not seen as the sole approach to assessing accessibility (Yesilada et al., 2015).

Farrelly (2011) also learnt that all of his participants had a positive attitude towards accessibility and persons with disabilities. However, despite the positivity, it appears that there are discriminatory beliefs and practices that impact the overall understanding of accessibility and its implementation. Farrelly (2011, p. 227) notes that although some discrimination was forward, most of it was "*subtle, well-meaning, or unintentional*". He considers that inattention in this case may be related to the seeming invisibility of persons with disabilities in society. Moreover, there seems to be a belief that accessibility is not only about human rights – on the contrary, it may not be required if persons with disabilities are not part of the potential customer segment (Farrelly, 2011).

Motivating factors

Previous studies have been able to identify a wide variety of potential motivating factors regarding accessibility. Interestingly, it appears that different organisations and practitioners may value different potential gains when it comes to implementing accessibility.

Accessibility implementation may bring **business value** to a company. Quantifiable benefits and the business case are some of the biggest interests that companies have when they are considering accessibility adoption or any new venture in general (Farrelly, 2011). Due to the increasing demand of accessible products, inaccessible systems will become more and more cost-deficient (Stephanidis, 2001). An accessible web service can increase revenue of a company (Martínez et al., 2014) by opening up new business opportunities (Leitner et al., 2016) and attracting more users by being easier to find and use successfully (De Andrés et al., 2010; Martínez et al., 2014). Accessible websites often rank higher on web search engine results which naturally leads to increased website traffic (Leitner et al., 2016; Yesilada et al., 2015). Wentz

et al. (2018) also underline the potential business impact as an important motivator for businesses.

Accessible products can be accessed by a much wider population (Leitner et al., 2016), including persons with disabilities and elderly people (De Andrés et al., 2010; Yesilada et al., 2015), as well as socially disadvantaged people (Yesilada et al., 2015). There are also circumstances when a person is temporarily disabled (a broken arm or lost glasses) or otherwise limited by their situation (e.g. by a small device screen) (De Andrés et al., 2010) and, thus, could benefit from accessible software. (Stephanidis, 2001) also argues that inclusive design is a user-centred approach that can help to improve usability on a wider perspective.

De Andrés et al. (2010, p. 77) state that although there are initial accessibility costs, such as evaluation, reparation and training costs, in the beginning of an accessibility implementation process, the "*costs are often offset by a full return on investment*". Furthermore, one study (Leitner et al., 2016) found that most organisations that have decided to implement accessibility noticed accessibility to be a positive long-term investment – accessible websites are low maintenance and easy to manage. Yesilada et al. (2015) argue that understanding the wide impact of web accessibility could motivate companies to make their digital products and services accessible.

Additionally, users with disabilities may also **demand accessibility** if they are unable to use digital products and services they need. It seems that accessibility-related feedback and requests may impact an organisation's motivation to implement accessible products (Farrelly, 2011). However, it appears that due to social structures few people with disabilities end up voicing their problems and concerns (Farrelly, 2011) which may create a false sense of satisfaction. Still, when Extra Costs Commission (2015, p. 7) investigated costs faced by persons with disabilities, they learnt that "*three quarters of disabled people have left a shop or deserted a business because of poor disability awareness or understanding*" or even poor treatment. Thus, inclusion of persons with disabilities has a potential to improve the market by up to 20% (Extra Costs Commission, 2015).

More accessible software can also increase the **operational efficiency** of a company (De Andrés et al., 2010). Martínez et al. (2014) estimate that adopting web accessibility can increase the operational and overall performance of a company. It can both reduce the information system costs and customer service costs as the users can operate online more efficiently (Martínez et al., 2014). Furthermore, Yesilada et al. (2015) note that inter-

operability can lead to increased revenue, emphasising the profitability of accessibility.

Accessibility can also be seen as a matter of **software quality**. As the majority of accessibility issues are of a technical nature and many of them are related to HTML semantics, implementing accessibility can increase download speed and the overall website quality as well as usability-related factors such as simplicity and clarity. Matters of technical quality are often brought up by IT experts who see the technical value of making accessible web services. Leitner et al. (2016) tell that some of their technical interviewees had been driven towards accessibility due to the low satisfaction, usability and traffic of their old website. The results of accessibility implementation are positive from a technical perspective – it has been reported to decrease maintenance and training times and costs as well as device and browser independence. (Leitner et al., 2016)

Another potential inspiration for organisations to implement accessibility would be **ethical factors** and **social responsibility**. Yesilada et al. (2012) found that social aspects of accessibility can drive practitioners in their work. More specifically, inclusion and ethical factors are the main motivators for the majority of practitioners to consider accessibility (Yesilada et al., 2012). The feelings of responsibility and empowerment may also inspire practitioners in their accessibility work (Farrelly, 2011). Ethical reasons can also be connected to potential loss and increase of profit. By implementing accessibility, companies reduce the risk of creating a negative image as an excluding service provider or producer (Leitner et al., 2016).

Corporate social responsibility (CSR) as a topic started to attract attention in the 2000s (De Andrés et al., 2010). CSR can be defined as "*the responsibility of enterprises for their impacts on society*", including human rights as well as other kinds of social, environmental, ethical and consumer concerns (European Commission, 2011, p. 6). In 2000, the EU took an official stance on CSR by appealing to "*companies' sense of social responsibility*" (De Andrés et al., 2010, p. 80). Accessibility is seen as a part of CSR due to its status as a human right. In 2018, the UN Human Rights Council adopted a resolution (UNHRC, 2018) where human rights on the Internet and online freedom are highlighted.

Several studies (De Andrés et al., 2010; Olalere and Lazar, 2011; Wentz et al., 2018; Yan and Ramachandran, 2019) have highlighted the increased **legal activity** regarding digital accessibility. Especially in the USA, accessibility lawsuits seem to appear regularly and often with a sizable cost for the

company offering an inaccessible service. Due to the new legislative actions in the EU, it is likely that both public and private bodies with inaccessible products and services will start facing lawsuits. The threat of legal action provides additional motivation for different actors to start working on their level of accessibility.

However, the respondents of some studies seem to be on average neutral about the role of legislation as a driver of accessibility (Vollenwyder et al., 2019; Yesilada et al., 2015). Farrelly (2011) even found that several participants of his study involving 23 web practitioners argued against accessibility legislation due to seeing universal access as something unnecessary. Moreover, Vollenwyder et al. (2019) learnt that a sizable section of their participants did not have knowledge about the legal requirements of their organisation. It has also been considered that even if practitioners knew about the legislation, limited knowledge regarding accessibility implementation in practice may still lead to the low level of accessibility (Power et al., 2018).

De Andrés et al. (2010) classify different types of factors that may influence a company's decision to work on accessibility into three groups: *operational factors*, *financial factors*, and *factors related to the company's CSR strategy*. Leitner et al. (2016) similarly group motives they found into three groups. The groups, however, were *economic motivations*, *social motivations*, and *technical motivations* (Leitner et al., 2016).

The different classifications had similarities with each other. They both identified financial and economic factors as a key driver for accessibility implementation. Social factors were also discovered. The unequal groups were related to operational, technical and legal motives.

There are studies (De Andrés et al., 2010; Leitner et al., 2016; Martínez et al., 2014) that have looked into accessibility implementation from the perspective of potential motivators. Some of their angle has been to assume, in the form of hypotheses, that companies which have more reason to be motivated by the impact of accessibility are also more likely to implement accessibility. These hypotheses have been tested through an accessibility evaluation of websites of a selection of companies, and comparing the evaluation results of different types of companies. (De Andrés et al., 2010; Martínez et al., 2014)

De Andrés et al. (2010) found that web accessibility seems to be implemented based on operational rather than social or financial factors. There was no significant impact on financial factors, and their analysis implies that CSR activism might even have a slightly negative influence on the state of

accessibility (De Andrés et al., 2010). Martínez et al. (2014) looked into both social and financial factors and report similar results. Additionally, they studied the impact of company size in implementing accessibility, and found no significant difference between different sized companies (Martínez et al., 2014).

In neither of the studies were company representatives approached to investigate whether the companies concerned had indeed considered benefits of accessibility and deliberately decided to work on accessibility of their websites. However, absence of accessibility awareness can lead to poor accessibility implementation (Leitner et al., 2016). Thus, this could be perceived as a weakness of some of the existing research on the impact of motivators in accessibility.

Leitner et al. (2016) studied accessibility from two directions. They looked into both the state of accessibility of selected websites, and interviewed their practitioners to learn about their motives and experiences related to accessibility implementation. They learnt that although only a fraction (12%) of the websites evaluated were deemed accessible, the organisations that had decided to adopt accessibility did have similar motives behind their decision. This approach brings more depth into the study and results of Leitner et al. (2016).

Overall, it can be said that all the different potential motives can be traced down to economical benefits and value. For example, operational improvements decrease related costs, and more easily manageable software leaves time for technology experts to work on other tasks. Even the ethical factors are connected to monetary value due to an impact that a negative image could do to a company. Thus, accessibility has numerous benefits for organisations and companies that decide to implement it.

Enablers and supporters

Although motivation is essential for accessibility transformation, certain level of preparedness is required to make it possible. For example, it is difficult to implement accessible products and services if the practitioner has no or little necessary **knowledge** regarding digital accessibility. According to Yesilada et al. (2015), their results imply that accessibility should be taught alongside HCI and UCD, not as an isolated topic, and accessibility education should inform both about the wide impact of accessibility (i.e. improving usability for

everyone) and that accessibility divides opinions within practitioners. Katsanos et al. (2012) suggest a project-based learning approach. Accessibility and related challenges and solutions would become more concrete for learners if they had an opportunity to explore possibilities of accessibility implementation in a project environment instead of through out-of-context guidelines and examples (Katsanos et al., 2012). Some organisations have management tools that support knowledge sharing between employees and help transfer tacit to explicit knowledge (Leitner et al., 2016).

Leitner et al. (2016) found that **key persons** or **champions** who were ready to work on accessibility initiation in organisations had an important role across all the different sectors they studied. All of those key persons had a clear **personal connection** to accessibility, whether it was through a personal experience (family members, friends or colleagues with disabilities) or business understanding (family members, friends or colleagues as accessibility experts) (Leitner et al., 2016). Similarly, Farrelly (2011) learnt that personal contact and continuous exposure to persons with disabilities has an impact on the perceptions of accessibility. These findings highlight the importance of creating connections between digital practitioners and real users, in this case persons with disabilities.

Accessibility **guidelines** can be a helpful tool in improving web accessibility. However, they alone seem to be insufficient in successful accessibility implementation. Therefore, working together with **experience experts** to support accessibility implementation would benefit the whole process. (Farrelly, 2011; Power et al., 2018)

Challenges and blockers

There are also major challenges and blockers in developing more accessible websites, including lack of training, managerial support and client support as well as confusing accessibility guidelines (Lazar et al., 2004). Farrelly (2011) and Katsanos et al. (2012) also argue that lack of appropriate accessibility **education and training** for digital practitioners is an important reason behind the high level of inaccessibility. One study (Farrelly, 2011) found that practitioners who had implemented accessibility in their work had to educate themselves to be able to do it. Long-term sustainability of education was also brought up due to high turnover of staff (Farrelly, 2011). Moreover, there are also cases when persons who have called themselves accessibility experts have misused their status and misadvised their clients (Farrelly, 2011).

Lack of accessibility awareness and misunderstandings regarding accessibility can also lead to inaccessibility as practitioners might not understand the full concept of accessibility (Leitner et al., 2016). However, if practitioners do not encounter people with disabilities and media coverage of accessibility and disabilities in popular or trade media is small, it can be difficult to gain any other information than stereotypes (Farrelly, 2011).

Some organisations also bring up initial **costs** of accessibility (Leitner et al., 2016). There are practitioners who have experienced that accessibility transformation may lead to significant costs (Farrelly, 2011). Limited budgets and resources may cause practitioners to postpone or even ignore accessibility implementation (Farrelly, 2011).

One of the main problems regarding accessibility implementation concerns the already existing **guidelines**. They often take a context-independent and formal format, making it difficult for practitioners to understand them and implement them in real-life situations (Farrelly, 2011; Katsanos et al., 2012). Additionally, there is no single solution that enables websites to be completely accessible for every person, regardless of their abilities, capabilities or disabilities (Katsanos et al., 2012). WCAG especially has been criticised for its difficulty, length and lack of clarity (Farrelly, 2011).

When it comes to requirements, different companies and organisations often have their own guidelines for different teams to follow. Leitner et al. (2016) learnt that strict design requirements may not conform with accessibility requirements, especially in large and multinational organisations, leading to accessibility initiatives failing. (Leitner et al., 2016)

Additionally, if a website and its content are edited by multiple persons, it is more difficult to regulate accessibility quality. This may originate from both human error and negligence. Hence, **quality assurance** has been reported as an implementation-related challenge by practitioners. It can be difficult to double-check every element on a website, especially when the website is large and there are several content creators, which indicates challenges in resources. (Leitner et al., 2016)

Suggestions for improving accessibility

According to previous studies and the literature review of this thesis, there seems to be little research on improving accessibility from the practitioner or organisational point-of-view. However, studies on factors that may impact

accessibility implementation are the first step towards successfully integrating accessibility into project work. Some studies also provide some support for the next steps.

Farrelly (2011) constructed the *Expanded Web Accessibility Integration Model* (EWAIM) based on his 23 interviews with web practitioners, a literature review and the original Web Accessibility Integration Model by Lazar et al. (2004). The aim of the EWAIM is to identify different factors that impact accessibility and, thus, provide support in accessibility adoption. The model consists of five sections: societal foundations, stakeholder perceptions, web development, tools and resources, and end user (Farrelly, 2011). The EWAIM summarises different factors that impact web accessibility implementation efficiently into one figure and it appears to be in line with other research on accessibility implementation-related factors.

Olalere and Lazar (2011) conducted an accessibility evaluation of 100 US federal homepages to gain an understanding of the state of accessibility. They take note that as accessibility laws and regulations already exist, there is a good foundation for future accessibility work. They conclude their study with some recommendations for improving accessibility procedures (Olalere and Lazar, 2011).

First, Olalere and Lazar (2011) state that accessibility processes should be made transparent and compliance plans public to hold governmental bodies accountable. Second, they argue that accessibility resources and guidelines should be improved. They should also include practical information about compliance processes and best practices for different actors to follow. Finally, it is highlighted that agency-specific training and manuals should be offered to employees to increase knowledge and ensure accessibility of digital services (Olalere and Lazar, 2011).

Chapter 3

Methods and Materials

This chapter introduces the methodology and materials used to study the research problem. The empirical part is conducted as a combination of case study and constructive research. The research approach is introduced and discussed to provide a solid ground for the research conducted. Then, the data collection process is presented from the preparatory stage through to the final execution. Lastly, the phases of data analysis are presented.

3.1 Research approach

In its simplest form, *qualitative research* can be seen as an approach where selected, non-numeric data types and analysis methods are used (Eskola and Suoranta, 1998). It is commonly used in studies that takes place in the natural world and have a clear contextual focus, or when only little is known about the research topic (Marshall and Rossman, 2016). It is especially useful when the aim is to understand a complex social phenomenon (Eskola and Suoranta, 1998), and perhaps even create change (Marshall and Rossman, 2016).

According to Yin (2018), *case-study research* is relevant for answering "how" or "why" questions that seek to explain some complex contemporary phenomena. It is especially suitable if a research topic requires a more in-depth focus while retaining a holistic perspective, and when the phenomenon and context cannot be clearly separated. Case study results may be expanded

and generalised to other reminiscent contexts, and more extensively if the case study is replicated under different conditions (Yin, 2018).

Lukka (2003) describes the *constructive research* approach as a sub-method of case study research. It is a procedure for producing innovative constructions with an intention to solve problems in the real world and, simultaneously, make a contribution to the related theoretical side. Constructive research often involves an attempt to test the practical applicability and effectiveness of the construction (Lukka, 2003).

The aim of this research is to show how accessibility is taken into account in agile software development in an organisation where accessibility is not part of the development process, understand challenges that lie in actualising accessibility, and present a process through which software development teams and organisations can improve the accessibility of their digital products and services. No previous research has been found about accessibility realisation and related change in software development processes. Combined with the aim of creating a wider understanding of the topic, qualitative data and methods are deemed suitable. The case study methodology is appropriate for looking into accessibility realisation and challenges as they are tied to a real-world context, in terms of both the culture of the company and the general atmosphere regarding accessibility. Moreover, the literature review carried out here shows that case study is a commonly used method to approach the state of web accessibility. Additionally, the constructive research approach is an appropriate research angle as the question of how accessibility could become part of the software development cycle with minimal resources is practically relevant. The research also has potential for theoretical contribution as there seems to be an opening for accessibility-embedded process guidelines in academic literature (see Chapter 2 for the literature review).

The angle of this study is an embedded single-case study. A single-case is appropriate because of the revelatory nature of this study. According to Yin (2018), if the researched phenomenon has been previously unacquainted, it is justified to use a single-case study. Nonetheless, the versatility is increased due to the case organisation being a large company and interviewing and observing multiple fairly independent teams. Yin (2018) states that subunits in an embedded single-case study can improve the opportunities for extensive analysis. However, using multiple units can easily cause a shift in the nature of the case study if the holistic aspects of the case begin to be ignored (Yin, 2018). Thus, to keep the holistic perspective in this study, the team data is usually handled as a whole, regardless of the team.

3.2 Data collection

The main set of data for this research comprises thematic interviews conducted with three software development teams in the case company. Interviews are supported by observations that took place at the case company between 15 April and 15 October 2019, an accessibility evaluation of the services provided by the aforementioned teams, and benchmarking interviews to widen the understanding of accessibility in software development. It is common to presume that a mixed method research combines qualitative and quantitative methods. However, Morse (2009) argues that a qualitative-only study can also be called a mixed method research if the core element of the study is supported by other sources of evidence creating one coherent study. Leveraging both method and data triangulation in a single qualitative study, the validity of the research can be enhanced (Eskola and Suoranta, 1998).

Two accessibility experts were interviewed for the sake the researcher's further understanding of the current context of accessibility work. Additionally, some parts of the accessibility embedding process were evaluated by development team members which also impacted the evolution of the process. For an overview of the different sources of data used in this study, see Table 3.

Next, the team selection and interview process, observations, accessibility evaluations as well as process testing sessions and interviews are described, starting from planning and preparations and ending with descriptions of the eventual data collection.

3.2.1 Team and participant selection

Within the case company, there were three factors that had an impact on the selection of teams for the interview and observation part.

First, the type of digital service was the first factor to narrow down in the selection process. As a Finland-based company that offers products and services for EU citizens, the case company is required to follow the upcoming EU directive (2019/882) on the accessibility requirements of products and services (European Union, 2019). The scope of associated products and services is listed in the directive. Out of five product and six service category types listed, the case company offers physical products from one of the product categories as a part of a service and digital services from four categories.

	Description	Extent
Primary	Thematic interviews: Development teams (16) - between 7/5 and 25/6/2019	Designers, developers, testers and POs from three (3) different development teams. Length of the interviews was between 30 and 57 minutes, altogether 10 hours 57 minutes.
	Thematic interviews: Organisational context (4) - between 16/5 and 1/7/2019	Managers, directors and teams with different responsibilities. Length of the interviews was between 34 and 52 minutes, altogether 2 hours 41 minutes.
	Process evaluation sessions and interviews (4) - sessions held and interview answers received between 13/9 and 1/10/2019	Introducing accessibility evaluation tools and methods for designers from four (4) different teams and doing some concrete evaluation based on user stories. The length of the sessions was between 1 hour 45 minutes and 2 hours, altogether 7 hours 30 minutes. Each session was followed by a six-question open-field email interview.
Secondary	Accessibility evaluations (3) - between 3/6 and 31/7/2019	Three (3) digital products and services that are developed by the interviewed development teams. Manual evaluation supported by digital tools.
	Observations in the form of field notes - between 15/04 and 15/10/2019	Notes from regular work day observations to meetings and planning sessions. 112 days spent on the field.
	Accessibility expert interview - 11/6/2019	Accessibility expert Tapio Haanperä from the Finnish Association of Intellectual and Developmental Disabilities (FAIDD). The length of the interview was 1 hour 4 minutes.
	Benchmarking expert interview - 13/9/2019	Accessibility expert from a public sector organisation. The length of the interview was 2 hours 14 minutes.

Table 3: Sources of data used in this study.

Consequently, the teams developing these services were the ones of particular interest as working with them could provide important practical insight for future reference for the company.

Second, team stress levels at the time of study and, hence, the potential amount of time that team members would have for interviews and conversations were taken into account. The interviews and observations took place in late spring and early summer, which is often a busy period of time in offices located in Finland due to the upcoming holiday season.

Third, the overall state and major goals of the product development in the candidate teams was estimated. It was noted that the fruitfulness of opening up a conversation around accessibility could be more or less fruitful depending on that the existing state of the development and the associated goals. Out of the candidate teams, only one team was in a positively critical point having recently begun a user-centric redesign process of their whole web application whereas others were mainly focusing on individual feature updates and bug fixes.

The company offers both business-to-business (B2B) and business-to-customer (B2C) services for a variety of clients. However, the scope of this thesis was set only around B2C services. Moreover, many B2C services have their own corresponding B2B services. Therefore, many findings from B2C services can be applied to B2B services as well.

In the end, the three teams selected for interviews and observations were mainly producing the following services:

- Customer self-service platform (Team A)
- E-commerce website (Team B)
- Audio-visual media service (Team C)

For more information, see the description of the case company and teams in Chapter 4.

Within each team, the interview participants were first and foremost selected based on their roles. Important to note is that developers had the greatest representation in each team, yet interviewees were randomly selected with the result that not all developers in each team were interviewed. Developers were randomly selected still making sure that there was a variety of development years behind them.

Out of the eleven designers and developers interviewed, eight were external consultants. The partially external team make-up raised a question of who should take part in accessibility embedding process testing sessions in order to rule out potential knowledge loss when consultants eventually leave the case company. As a result, designers for the user path accessibility evaluations were pooled mainly based on the type of digital service produced by their team and its relationship to the European Accessibility Act (EAA), and the participant's status as a company employee. However, developers that were part of evaluation conversations were partially chosen due to their experiences in accessibility-promoting public sector projects. Thus, in their case it was crucial to include them in the sessions even though they were external consultants.

The participants were usually contacted face-to-face for the first time to initiate the conversation once the observation period had already started. After the first contact, it was easy to approach them through an instant message or email to agree on specific time and place for an interview.

3.2.2 Case interviews

Interviews are one of the most common and important methods for collecting qualitative evidence in case studies (Yin, 2018). When conducting interviews, it is advisable to select interviewees that have some knowledge regarding the topic (Tuomi and Sarajärvi, 2018). During interviews, possible misunderstandings can be easily clarified and questions that surface from the interview itself can be posed directly (Tuomi and Sarajärvi, 2018).

The objective of the case interviews was to find out about the state of software development processes and accessibility within each team as well as their personal knowledge and understanding regarding accessibility. In addition, the aim was to create an understanding of the organisational factors related to accessibility, including any new initiatives. Approaching these objectives through interviewing both team members (*team member interviews*) and managers of the organisation (*organisational context interviews*) was deemed suitable. Moreover, not much seems to be known about accessibility implementation from the team and organisation point-of-view, making interviewing at both levels a particularly fitting method for this research.

Thematic interviews are centred around a selection of themes that are all connected to the research problem, and they can be supported by questions

(Eskola and Suoranta, 1998). Style-wise, thematic interviews are positioned between structured and open interviews. The themes guide the whole interview process while new related questions can arise from anything the interviewee has mentioned. Different interpretations, thoughts and meanings that people have regarding anything and everything are emphasised methodologically (Tuomi and Sarajärvi, 2018).

Pilot interview

To prepare for the interviews, a pilot interview was conducted to verify that the designed interview frame and questions were both natural and suitable for the planned thematic interviews. Eskola and Suoranta (1998) state that it is more than appropriate to test interview questions and structure, just like any other research tools. The pilot interview was conducted on 6 May 2019 with a product owner who has some prior experience with developing and who has worked at a pilot company. The interview lasted for 36 minutes and it was held in Finnish, face-to-face. The results of the pilot interview are not included in this study.

The pilot interview helped in finalising a structure for the development team interviews. Although the interview themes stayed the same, more depth was added to the background information section, with the incorporation of the topic of accessibility background, and to the accessibility section in general. Otherwise, the interview frame and questions stayed the same. For the organisational interviews, the pilot interview helped to understand that a more open and even less structured thematic interview would be more suitable due to their unpredictable nature and also the highly different roles of interviewees at the organisational management level.

Conducting interviews

There were altogether sixteen development team member interviews conducted in three different teams and four organisational interviews. Multiple teams within the case company were selected to enhance the depth of the data set collected and decrease bias that could otherwise have formed based on interaction with a single team. All the interviews were conducted between 7 May and 1 July 2019, and they were held in either Finnish (17 interviews) or English (3 interviews). They took place at the company headquarters in Finland, except for one interview that was conducted as an online call.

Further information regarding each team member interview and organisational interview can be found in Appendix B.

Although the interviews were guided by the themes and initial questions, they were conversational in nature and, thus, the themes were not always discussed in the same order. Tuomi and Sarajärvi (2018) note that it is only a matter of taste whether the questions are all asked and in the same order with each of the interviewees. The organisational context interviews were the least structured out of the interviews due to their in-depth nature but still focused around the common theme of accessibility and its current and possible future involvement at the company.

The interviews were recorded with the permission of each interviewee. Initial notes were also written during the interviews. The recordings were used to create edited transcriptions of each interview. To ensure that the team member interview participants felt comfortable sharing their thoughts freely regarding the interview themes, the notes and transcriptions used in this study were anonymised. Moreover, for reasons of confidentiality, the interviews are not published.

Interview structure

The *team member interviews* were initially structured based on both the need to address the research problems at hand (the state of accessibility, related challenges, ways of working in teams and organisation in general and in case of new initiatives) and the researcher's own experience in user-centred design and software development. The pilot interview helped in further defining the themes and supporting questions, creating a solid interview structure.

The final themes discussed during each interview were:

1. accessibility knowledge and experience;
2. work in an agile software development team;
3. work in a large organisation; and
4. the state of accessibility and practical accessibility.

Before discussing the actual themes, the study was introduced, the general interview procedures were explained and the interview agenda was described to each participant, unless (as encountered in some cases) the participant

was so eager to start discussing accessibility that the introductions were left until a later point. Additionally, depending on the flow of conversation in each interview, the order of the themes discussed varied. In particular, the state of accessibility and accessibility experiences were often addressed throughout the conversation, rather than in a single section of the interview – additions were made and thoughts seemingly conveyed out loud whenever they crossed the mind of the interviewee. Thoughts and comments as well as feedback regarding the interview were asked after the discussion. The interview structure and objectives of each section are listed in Table 4.

In addition to the themes and objectives, there were more detailed questions and topics prepared that supported the researcher during the interviews. These questions were there only to support the interviewer and not all of them were asked in every single interview, depending on the flow and content of the conversation as well as the knowledge base of the informant. The more detailed list of these guiding questions and topics can be found in Appendix C.

The *organisational context interviews* were based on the same interview structure. In addition, as the product owner interviews were the most in-depth out of the team member interviews, the pilot interview provided good direction for the organisational context interviews that were even more in-depth due to highly varying approaches towards the topic. In these interviews, all the same themes were discussed than in team member interviews, except for the Theme 2 (work in an agile software development team). This was due to the roles or the interviewees – they were not part of the workflow of any single team and, thus, could not speak out on their behalf.

3.2.3 Observations

Observing is another common method for collecting data in a qualitative study. Observations can help to connect different pieces of information together, acting as an adhesive. Participant-observation is a form where the researcher actively interacts with the informants of the study and can take different roles in different situations (Yin, 2018). In this case, social interactions are an essential part of the data extraction process (Tuomi and Sarajärvi, 2018). The participant-observation technique has been commonly used when studying different social groups (Yin, 2018), making it a natural supportive method in this research.

Section	Objective
Introduction of the study and the interview process	Ensure that the interviewee has a clear understanding of the interview situation, and that they know that the results will only be shared anonymously both inside and outside the company.
Interviewee background	Gather background information of the interviewee, their role in the company and knowledge and experience related to the IT industry in general.
Theme 1: Accessibility knowledge and experience	Find out about knowledge, experience and understanding related to accessibility both in theory and implementation-wise.
Theme 2: Work in an agile software development team (team context)	Get on overview of the ways of working on a team level: agile framework and methods used in project management and implementation and communication within the team. Identify possible challenges and enablers regarding teamwork, design, technology and content creation.
Theme 3: Work in a large organisation (organisational context)	Become informed of how knowledge is shared within the organisation, how the company-wide design system and pattern library are utilised and how new initiatives become part of daily project life. Identify possible challenges and enablers regarding the organisation, design, technology and content creation.
Theme 4: State of accessibility and practical accessibility	Get an overview of the state of accessibility at the organisation, how it is realised and how a team member experiences the situation. Identify possible challenges and enablers regarding accessibility and its implementation.
End of the interview	Offer an opportunity to comment or discuss other related things freely. Get feedback from the interview itself.

Table 4: The team member interview structure and objectives.

Depending on the phase of the study, the observing role I assumed was different. In the beginning of the study, the focus was to find out about the pre-planning state of accessibility (when accessibility is not planned for). Thus, observing was more passive, concentrating on what happened in the daily life of each team. Still, the teams and other stakeholders knew the purpose of this research and therefore saw my presence as an accessibility-impacting influence and came forward with their accessibility-related thoughts, concerns and questions. These were some of the first formative conversations with the organisation members where the state of accessibility and possibilities for evolving the accessibility situation were discussed.

Halfway through the study, while I was finishing with the thematic interview phase, I began demonstrating to both designers and developers some of the different accessibility issues that had arisen during accessibility evaluations that I had conducted. This was the starting point for a more powerful formative dialogue that was emphasised towards the end of the study. While I was developing the process for the sustainable improvement of accessibility, it became increasingly important for me to have a fruitful, bidirectional dialogue with both development team members and managers of the organisation based on our mutual understanding of the common goal.

During the observation period, both hand and computer-written notes were taken to record events, comments and other observations. The material consists of content from casual moments and conversations during workdays to meetings of different levels of formality. This ensured that the supportive observation material is diverse and, thus, able to have an enhancing effect on the primary material.

3.2.4 Accessibility evaluations

The case company is a Finnish private sector company that operates primarily in the EU and will be subject to the EAA directive once it becomes applicable in 2025. Therefore, the metrics for the accessibility evaluations conducted in this study are based on the EAA. Although the regulations of the EAA are inspired by WCAG[1], the EAA directive does not comply with WCAG unlike the WAD.

[1]See e.g. recital 47 (2019/882) for the connection to the four principles of accessibility (European Union, 2019).

The importance of the four principles of accessibility (W3C, 2018a) in the context of the EAA are highlighted in its recitals. Thus, they are used as the base framework for the expert evaluation on accessibility of three digital services of the company. The evaluations were conducted on four parts:

1. Common technical accessibility issues using browser-based accessibility tools
2. User path walkthrough using keyboard to navigate
3. User path walkthrough using screen reader software and keyboard to navigate
4. Visual and cognitive overview of the website content

At the start, a user path was selected together with a designer of each service based on the crucial nature of the selected path. Each part of the evaluation was conducted on all the pages that a potential user would navigate in order to reach their final goal. The evaluations were run on an Apple Macbook computer, using either free or built-in tools.

For the first part, common technical accessibility issues such as HTML semantics and colour contrasts were evaluated using free versions of three accessibility tools. They were all browser-based, which allowed for an easy way to test web services, and they have been built based on existing accessibility rules and criteria such as WCAG and Section 508. The three tools used were Axe[2], WAVE[3] and Lighthouse[4]. Using all three of them instead of just one tool was opted for as, through testing, their comparative strengths and weaknesses were unveiled. For example, Axe has an extensive documentation library that can be reached easily through each issue found in an evaluation. Additionally, sometimes different tools were able to find issues that were escaped by others.

Second, the user path was completed using only a keyboard. This happened by using mainly three keys: tabulator, enter and space bar. A manual keyboard user testing was deemed necessary as automated tools cannot depict natural order of navigating a UI.

The third part was to carry out and navigate each action using a screen reader software and a keyboard. The screen reader software used was the Apple software VoiceOver which is used within the Apple users of the blind community (Gonçalves et al., 2018). Finally, the content of each evaluated

[2]Axe: `https://www.deque.com/axe/`.
[3]WAVE: `https://wave.webaim.org/`.
[4]Lighthouse: `https://developers.google.com/web/tools/lighthouse`.

page was reviewed for natural user flows and distinct grouping of elements, clear content and use of unnecessarily obscure language.

It was common that the same accessibility issue reappeared in several parts of an evaluation. However, there were always new issues that were revealed after each part, which highlights the value of a multi-part evaluation process using several tools. Moreover, after testing and iterating the evaluation process in the three evaluations mentioned here, it became fluent to use the same process in subsequent process testing sessions.

3.2.5 Process testing sessions and interviews

To get the first indications of the potential of the accessibility improvement process constructed based on case interviews and observations, some of the first steps of the process were executed. More specifically, the following steps were conducted:

1. Four accessibility evaluation sessions (one-on-one) with designers to evaluate the accessibility of a selected user flow and introduce and test free accessibility evaluation tools
2. Two accessibility information and demonstration sessions with an entire team

The expert accessibility evaluations acted as a base for the evaluation sessions. Each of the sessions was conducted face-to-face with only the researcher and a designer present, and they had been designed to last for two hours. As mentioned before, the participants were selected from the pool of designers who work on products impacted by the EAA and most of whom are case company employees (see Table 5 for details about each interview).

Before the sessions, the designers were asked to think of a key user path of their service to ensure a useful evaluation session. The sessions were constructed of the following sections:

1. Describing the content of the session
2. Downloading all the required accessibility tool browser add-ons to a designer's computer

C/E	Services	Session	Interview answers
E	Instruction website, self-service platform (web)	13/9/2019, 2 h, Finnish, face-to-face	17/9/2019
E	E-commerce website, main website of the company	18/9/2019, 2 h, Finnish, face-to-face	20/9/2019
E	Self-service platform (web)	27/9/2019, 1 h 45 min, Finnish, face-to-face	30/9/2019
C	Audio-visual media service sales website, audio-visual media service (web)	30/9/2019, 1 h 45 min, Finnish, face-to-face	1/10/2019

Table 5: Designer participants of process testing sessions and interviews. C = consultant, E = employee.

3. Going through the selected user path step by step using the following methods: three accessibility test tools (Wave, Axe, Lighthouse); keyboard navigation; screen reader (Apple VoiceOver); glance through to spot possible inconsistencies in the visual UI or understandability issues
4. Presenting the accessibility process cycle as a way to start improving accessibility

During the sessions, there was an ongoing conversation about the participant's feelings, thoughts and revelations regarding accessibility. Moreover, the designers received a short email interview of six questions about their experiences regarding the accessibility evaluation session afterwards to give them an opportunity to collect their thoughts after the initial accessibility immersion. The email interview questions are listed in Table 6.

Themes	**Questions**
Accessibility evaluation and current state of accessibility	What were your expectations regarding the state of accessibility? Did your views change based on our investigation?
	What kind of thoughts did the accessibility evaluation inspection inspire in you?
	What do you think you got out of our evaluation and tool-testing session? Describe which parts were the most valuable to you.
Future actions	Could you imagine using the same methods to follow up on the state of accessibility in the future? Why?
	Would you recommend a similar session and practices to your colleagues to evaluate accessibility? Why?
Additional comments	Would you like to add anything else?

Table 6: Accessibility evaluation follow-up questions send via email.

3.3 Analysis

The initial analysis had already begun during the case interview process. However, the systematic analysis process began after the interviews had been conducted by listening through interview recordings and transcribing them.

Field notes were also read through to gain a holistic understanding of the current atmosphere, knowledge and understanding regarding accessibility. This was an important starting point for the analysis as it is highly dependent on understanding the data (Taylor-Powell and Renner, 2003). At this point, the focusing of the material took place and the first initial categories also emerged from the data based on repeatedness and explicit connection to the research problem, such as *knowledge*, *empathy*, *business support* and *resources*.

The next step of the analysis was to identify themes and patterns within the focused data and organise them into initial categories (Taylor-Powell and Renner, 2003). I started by organising findings into larger emergent categories inductively and then iterated the content of each category into subcategories (Taylor-Powell and Renner, 2003). During this process, categories of different levels changed a lot and topics were moved from one category to another. The final categories and subcategories can be found in Table 7.

The actual coding and categorising was conducted both by hand using colour-coded sticky notes and by computer using the qualitative data analysis software ATLAS.ti[5]. The aim of the two-fold categorisation process was to ensure that everything of interest was considered in this thesis by focusing and categorising the research material twice. The process was found successful as the categories, subcategories and their content continued transforming during the second round of categorising.

After the categorisation was complete, it was possible to form an understanding of the initial state of accessibility based on the experiences, thoughts and assumptions of the participants. Based on this knowledge, I was able to start formulating answers to research questions and creating the construction. The second part of the analysis consisted of a lighter analysis of email interviews and notes based on four accessibility evaluation sessions conducted separately with four designers. The main objective of the evaluation sessions was to find out whether the accessibility evaluation sessions were found to be useful and educational, and whether they inspired practitioners to take action related to accessibility in the future. Thus, it was natural that the emergent categories were *increased knowledge*, *increased understanding*, and *future indications*.

Finally, the process was slightly iterated and built upon after the process evaluation sessions. The conducted evaluations even indicate that some of the first steps of the process may have a positive impact on creating a fruitful base

[5]ATLAS.ti: `https://atlasti.com/` [Accessed: 1/7/2019].

for future accessibility implementation work and may not require changes at this point. Therefore, most of the changes focused on further suggestions on the process. Table 8 presents the entire analysis process in a summarised form.

Categories	**Subcategories**	**Number of instances**
Concept of accessibility	Knowledge	22
	Understanding	16
	Business	11
	Legislation	4
	Process issues	14
Current challenges	Resources and priorities	20
	Technology	20
	Design	7
	Content	7
Design system experiences and implications	Benefits	7
	Challenges	12
	Wishes	4
Current state of accessibility implementation	First steps taken	6
	Strong state of design	5
	Designers' responsibility and trust in designers	9
	Team effort	3
Implications for accessibility implementation	Planning	4
	Increasing knowledge	6
	Identifying issues	4
	Practical implementation	21
	Programming	9
	New material	6
	Old material and bug fixes	10
	Audits	2
	Design system	5
	Testing and evaluating	15

Table 7: List of categories and subcategories that emerged during the analysis process.

Phase	Actions
Phase 1: Getting to know the initial data	Collecting narrative data in different forms to one place. Listening through interview recordings and transcribing them. Reading through the field notes.
Phase 2: Focusing the initial data	Focusing on topics and questions that rise from the data and that are related to the research problem.
Phase 3: Coding and categorising	Going deeper into data and organising findings into first larger emergent categories, then smaller groups within them and vice versa. Finding connections within those groups and categories.
Phase 4: Interpreting the initial data	Forming an understanding of the initial state of accessibility as well as related possibilities and challenges. Starting to create a finding-based accessibility-embedding implementation process model and evaluating it with development team members.
Phase 5: Focusing the evaluation data	Focusing on topics and questions that rise from the evaluation notes and interviews and that are related to the research problem.
Phase 6: Interpreting the evaluation data	Evolving the process model based on findings. Specifying future steps and methods for evaluating the process further based on findings related to the evaluation of the first steps of the process.

Table 8: Phases and related actions of the analysis process.

Chapter 4

Case Description

This chapter outlines the features of the case company and the three software development teams observed and interviewed during this study. The company information presented here is based on publicly available sources such as company websites and reports. The information about teams within the company, however, is extracted from the observation and interview sessions presented in Sections 3.2.2 and 3.2.3 as there are no public sources related to individual development teams and their ways of working. This case study has an embedded design and, thus, it is important to be able to understand how each of the subunits function within the scope of this research. This knowledge is also crucial to being able to understand whether the possible differences and similarities of the teams might affect their other characteristics and overall performance.

4.1 Case company

The company is a large Finnish telecommunications, ICT, and online services company. A significant number of its customers are based in Finland, although in addition to this they have an ever growing international clientele. Altogether, the company reaches over 2.8 million people, with more than 6.2 million telephone subscriptions being used by both personal, business and public sector customers.

In addition to an assortment of different types of mobile-broadband subscriptions and other telephone services, the company offers a variety of digital

products and services, such as digital television and audiovisual media services, e-book services, and e-commerce services for digital services and devices. Many of their products and services have both business-to-customer (B2C) and business-to-business (B2B) variants to ensure focused services that respond to the needs of customers.

The company employs circa 4,800 people out of which around 500 persons work as ICT specialists. Their areas of expertise vary between software architecture, management and customer-centred design and research. The department of digital services develops and creates most of the company's digital services and it consists of international product teams that use English as their working language.

There is a company-wide design system and pattern library that provide a uniform visual style for the company's full suite of different services. They help development teams create services that feel like part of the same family.

4.2 Teams

All the product development teams at the company are in charge of the service they are designing and developing. They work using different agile methods and approaches to support their goals of rapidly improving and updating their product. The development teams are very independent and have been able to choose appropriate agile ways of working for themselves.

The company offers a wide variety of digital services and the design system and pattern library combination aims to ensure the common feel of all of them. In addition to the shared design system, designers of the company currently meet twice a week to share knowledge, discuss the challenges they have faced and support their colleagues with out-of-the-box insight. Four out of five designers have experience in frontend development and enhance their knowledge by discussing development-related topics.

Due to the variety in the company's service selection, each service of the three selected teams is quite far from the others in terms of their functions and objectives. Moreover, the teams are of different sizes, they are at different stages as regards the lifecycle of the project, and the content of their core activities varies. Next, all the three teams that were part of the team member interview processes are introduced in more detail. All the information

is based on the state of each team during the observation period; possible changes that have taken place since then have not been taken into account.

4.2.1 Team A

The product of Team A is a self-service platform to personal customers. It offers tools for customers to manage their mobile subscriptions – for example retrieve a PUK code – and other services provided by the company that the customers may use. The team is currently working on a complete redesign of both the web platform and mobile application experience to improve ease of use and customer experience, thereby placing more weight on their long term planning.

The product development is led by a *product owner* (PO) and a *technical product owner* (TPO), who are in charge of what is being done (PO) and how it is done (TPO). The PO also acts as a proxy of business, keeping the business aspects in mind at all times. They are joined by twelve team members whose tasks vary from design to development and testing. The two *designers* work on both user experience (UX) and user interface (UI) design. They share their tasks, although usually only one ends up taking the ownership of designing a certain feature. There are nine *developers*, and they are all full-stack developers. They work on both frontend and backend related tasks. However, some of them have more experience and knowledge in one or the other. Finally, there is a *tester* who mainly works on UI-based automated tests to ensure that the required elements are found on each page and that they work correctly in different situations. Except for the PO and the TPO, everyone in the team is a consultant.

Team A uses a modified Kanban as their project framework. They use a mixture of both physical high-level Kanban board for long term planning by their work station, and a more detailed digital one with precise tasks available online. Only the most upcoming tasks have been prioritised, and usually only the ones that are currently worked on have been scheduled with deadlines.

There is a daily meeting every morning at 10am to go through what was done the day before and what is planned for that day. In addition, there is a mobile application-related weekly meeting every Wednesday and an overall team retrospective every three weeks. A web platform demonstration event takes place once a month, unless it is postponed due to the lack of illustratable

new material. Of these meetings, retrospectives of the team are those that focus least on specific tasks and features, and more on the overall ways of working and feelings of the team members.

The whole team sits in the same space at the office, except for the two offshore developers who join all the meetings online and communicate with other team members through online means, including the chat platform used at the company. The designers sit together with the PO and the TPO in one table group to enhance their day-to-day communication. Next to them, the developers and the tester share another larger table group for easy communication.

Team A works closely with the team for the B2B counterpart of their product. Additionally, other product teams approach them with their ideas for backlog items, when they have something in mind related to their service that is displayed in the self-service platform. Otherwise, the designers try to keep track of what other teams are working on and whether there are potential occasions for cooperation.

4.2.2 Team B

The product of Team B is a B2C e-commerce website that sells both digital products and services and physical, mostly electronic, products. The team consists of nine members. The *PO* and *TPO* run the project and try to prioritise the tasks that are brought in by multiple different stakeholders. There are five *developers* who are all full-stack developers. However, most of the current development happens in the backend and is related to maintenance or supporting other teams with their e-commerce related problems. There is also a *designer* who works three days a week on the project. Additionally, they also support other teams who have a need to impact the e-commerce website during those three days. Finally, there is a *tester* who mainly works on UI-based functionality testing by both building automated tests and doing manual testing. The PO, the TPO and the lead developer are all employees at the company, but otherwise the team consists of consultants.

The project framework that Team B uses in an adapted Kanban that some team members even call Scrumban due to a selection of features that have been borrowed from Scrum. The ideology of Kanban fits to their project and way of working because new surprising tasks come along all the time – it would be hard to plan for a two-week sprint and try to aim for the set

objectives. They mainly lean on their physical Kanban board in both daily and long-term planning.

Daily meetings are run every day at 9.50am, making sure than even if all else fails, the dailies are still there. During dailies, tasks between developers are divided evenly, ensuring that everyone gets a variety of different types of tasks. In addition, there are backlog groomings when needed, usually in every few weeks. During a grooming, the development backlog items of highest priority or urgency are raised onto the queue. After the queue has started to become shorter again, a new grooming is scheduled and more items are added. However, a lot of tasks with even higher urgency are reaching the team in other ways, with the outcome that there is little time to unpack the queue. If a larger development topic such as for example, a new feature comes up, then tickets related to that topic are usually groomed separately. There are also regular retrospectives, once every one or two months.

All the members of Team B sit in the same space. The PO, four developers and the tester sit at the same table group, next to a second table group occupied by one developer and the TPO of the team as well as members from other teams. Next to their seats, there is a corridor and on the other side of it, the designer of the team sits together the design system team. Dailies are held next to their Kanban board for the ease of planning while other meetings usually take place in meeting rooms around the office.

Team B works closely with all teams who have any sort of connection with the e-commerce website. These include teams whose products and services are displayed at the online shop or who are somehow connected to the shopping experience, for example product delivery. Moreover, a great part of the code in the website comes straight from other teams – if delivery options are updated, the team responsible for deliveries makes the update themselves and sends it over for the online shop team to review. These are also cases in which the designer needs to support other teams to ensure a uniform experience across the e-commerce service.

4.2.3 Team C

Team C is part of the wider audio-visual media service team of around 50 developers, designers, testers and business and product owners. The service consists of multiple parts and it can be used on a television, computer or

mobile device. The main responsibility of Team C is to contribute to the web service that can be used for streaming media content.

The team is led by a *PO* and a *TPO* who both have their own focus and priorities to address. The PO is the business driver of the team, taking care of the business aspects, whereas the TPO has a more technical role. There are only four *developers* in the team. Two of them concentrate mainly on backend development, while the other two work on other tasks flexibly, usually related to the frontend. There is also a *designer* who takes care of both UX and UI design as well as a tester in charge of developing and running test automations. A *service designer* with a holistic perspective to the overall service works together with all the audio-visual media service teams. Additionally, there is a Scrum master who supports multiple audio-visual media service teams while not fully being part of any individual team.

The project framework used by Team C is Scrum which, instead of being used dogmatically, has been adjusted for the team. There are two-week sprints and the team has daily meetings that structure their work. The daily work is supported by a sprint review, which takes place after each sprint, and a sprint planning which sets a stable starting point for the next one. In addition, Team C runs PDCA workshops once a month to make sure that they take time to reflect and react on their reflections. The minimum viable product (MVP) thinking plays a central part in their work routines, and they try to publish new versions as often as possible.

Team C works closely with other teams who work on the audio-visual media service. The designers from all of those teams sit together for mutual support and to ensure visual unity of the different parts of the services. The developers also work with other teams, especially those whose tasks are also related to web development – with them, it is even possible to share tasks sometimes. On a business level, there is a high volume of communication between these teams due to their common objectives.

Chapter 5

Results and Analysis

In this chapter, the results of the case study are presented. The results are laid down according to themes that arise by inductive reasoning from the collected material. This allows for a natural comparison between the thoughts and experiences of the interviewees regarding different areas of accessibility inclusion in organisation-based agile software development.

Due to the organisational structure in the case company, it would be possible to connect participants with their identities within the company if both their teams and roles were carried along in the results. Therefore, only their roles or their teams are mentioned in this chapter. For the ease of understanding and internalising results, the participants from product teams are referenced according to Table 9 where the participant order has been randomised. The teams are referred to as Teams A, B and C as introduced in Chapter 4. The roles of the organisational interviewees are described in this chapter.

Designers	**Developers**	**Testers**	**Product Owners**
Designer A	Developer A	Tester A	Product Owner A
Designer B	Developer B	Tester B	Product Owner B
Designer C	Developer C		Product Owner C
Designer D	Developer D		
Designer E	Developer E		
	Developer F		

Table 9: Product development team participants.

First, the context of experiencing accessibility and its relationship with the software industry is described. Second, challenges regarding the incorporation of new elements such as accessibility into a project are presented. Finally, experiences of and thoughts on embedding accessibility into both software team and organisation activities are cited.

5.1 Preconceptions of accessibility

General accessibility knowledge and understanding in a software company is described in this section. Moreover, thoughts related to business and legislation aspects of accessibility are discussed.

5.1.1 Understanding accessibility

The interviewees seem to have an initial understanding that accessibility is about creating services that can be easily accessed by people with disabilities. When talking about digital accessibility, the first example of a user that many participants come up with is either a blind or otherwise visually impaired user. Similarly, there is a prejudice that accessibility is something that only a small minority may benefit from. However, Designer B and C bring up that accessibility is not only about improving use conditions for visually impaired people, but for so many others as well, among them people with learning difficulties and motoric challenges. Designer C describes their experience with other practitioners as follows:

> "*I am really shocked when a [designer] colleague says that accessibility is ... for blind people because accessibility is not just that. There is such a wide spectrum of disabilities, there is no single group of disabled people. And you might break your arm or lose your voice one day. Then you might actually be really happy to have access to those accessible things.*" (Designer C)

Multiple designers also argue that improving accessibility could improve **usability** and user experience for everyone (Designers A, B, C and E). In addition to designers, POs and developers also see the connection between accessibility and usability and the importance of them at an ideological level

(POs B and C; Developers A, B, D and E). Designer A assesses the relationship between usability and accessibility and describes it thus:

> "*It could even be said that accessibility is usability that has been quantified. ... Only in accessibility we have got numbers for things. ... They [usability and accessibility] do not mean the same thing but, in a way, what should and could be accessed has been brought to a more precise level.*" (Designer A)

On the other hand, understanding the connection between usability and accessibility can generate misunderstandings. Some developers see that accessibility is something that is mostly related to designers' actions instead of being a team effort (developers A, C and F). However, some designers highlight that although good design should be accessible to start with, there is not much a designer can do if services are not also developed in an accessible way (designers B, D and E).

Two of the three POs mention that it would bring value to the organisation to have a clear understanding of **why** accessibility is in fact **important** (POs B and C). In addition, knowledge of whom accessibility could benefit and in what situations would be beneficial in promoting accessibility in a company environment (POs A and B). Although ensuring access for persons with disabilities is seen as an important reason, it may not be enough to drive change: "*I would not want that any of us has to think that [an action] only improves accessibility and that is it – there needs to be something else, some other benefit*" (PO A).

Many of the interviewees who had a prior understanding but no experience of accessibility are unsure where they should start if they were to work on improving accessibility. Accessibility can be seen as something **intimidating** because there are numerous features and improvements that could fit under the umbrella notion of accessibility, including different language versions (POs B and C; designer B). The uncertainty of the scope is also used as an excuse not to act on accessibility: "*There are surprisingly many things that you have to take into account, so it is natural that ... some things do not get all the possible attention*" (PO C).

Designer B also explains that when they really understood the impact of accessibility and inaccessibility, it became difficult not to take ownership of the matter: "*It is our job to make services with good usability – we do not really have a choice [regarding accessibility]. It is something you have to embrace,*

take over and understand." (Designer B) The Responsibility Director of the company and Designer C both highlight that taking care of accessibility is part of the **social responsibility** of a large company as a significant player in the community. Moreover, the Responsibility Director underlines that accessibility is a human rights matter:

> "*We always say that people are oppressed in developing countries ... but accessibility is also a human rights question and about everyone having the same options and opportunities. That is an amazingly big theme, and it will become bigger and bigger a theme for technology companies in the future.*" (Responsibility Director)

It appears that the depth of the overall accessibility understanding is dependent on the disability-related experiences and encounters that practitioners have had in their lives. For example, Designers B and D have both been able to observe persons with disabilities interacting with a web service and seen the encountered issues first-hand. Similarly, Designer A has attended an accessibility lecture during their university studies, and the guest lecturer of that lecture was blind. The practitioners with a **personal and empathetic connection** also feel strongly about the importance of accessibility. Observations at the case company show similar signs as there were several encounters with persons who felt especially strongly about accessibility and who had a personal accessibility or disability connection.

5.1.2 Accessibility knowledge

Although participants seemed to have some knowledge related to accessibility, there were still many missing puzzle pieces to their understanding. Hence, one of the biggest highlights from the material is a **lack of knowledge**, especially on developers' side. Three out of six developers (Developers B, D and E) mention that not all developers know much about accessibility and how to pursue it in the code. Similarly, Designers B and E refer to the lack of knowledge. An example that is raised commonly is HTML markup semantics: "*I have observed that a general developer does not really know about the fundamentals of HTML semantics and structure*" (Designer E). The lack of knowledge is also visible in other comments. For instance, Developer C notes that they have never been obliged to consider accessibility.

The knowledge base was the strongest if an interviewee had accessibility **experience** from a previous project. Out of six developers, three had expe-

rience in concrete accessibility implementation due to public sector projects they had worked on before joining their current projects at the case company. Two of them were developers, whereas one had a project lead role and, thus, had more knowledge of the overall advancement of accessibility in a development team. The most experienced developers were also the ones that seemed to be the most aware of their own knowledge gap in certain aspects of accessibility.

The interviewed designers appeared to be more confident in their accessibility knowledge and related skills. Two out of five designers had a strong view that a professional designer knows how to design good usability and, hence, good accessibility (Designers D and E). Still, Designer E highlights that there are things that designers could also do better. However, it would not make much of a difference if accessibility was only left to be the responsibility of designers (Designer E).

The lack of knowledge is not only a challenge for developers. Both designers, testers and product owners raise this issue in their work. Moreover, the importance of being able to access training and learning material to increase accessibility knowledge and awareness was mentioned by eight team members from all different roles (PO A; Designer C; Developers B, C, D, E and F; Tester B). Developer F even inquires: "*When are we going to get guidelines on how to fix those [accessibility issues], checklists, or [suggestions of] new ways of working?*" (Developer F)

Knowledge can also become lost if it is not sustained. This is especially the case if a team mainly consists of consultants from external agencies, as team member turnover can be higher than it otherwise would be. As a result, **lost knowledge** can turn into an issue. This was brought up by five participants from the product teams (Designers B, C and E; Developers A and F). However, one participant mentions that they do not see any knowledge-sharing issues within their own team as there is "*some documentation and all team members have never left at the same time*" (Developer C).

5.1.3 Business and legislation in relation to accessibility

It is the nature of any business to be concerned about the **business value** of new ventures. Designer C points out that many business people do not know about the business opportunities and potential risks of accessibility, inclusion and exclusion likewise, making it easier to ignore accessibility. As the busi-

ness stakeholders of each product development team, all the POs interviewed brought up the business aspects of accessibility and were interested in them. PO B describes the common business evaluation of every new venture: "*We would need to estimate how many customers this [accessibility] influences, or if there are any other [financial] reasons that would turn accessibility into a profitable fix*" (PO B).

The Responsibility Director notes that inclusivity and equality are values that the case company and other teleoperators emphasise. However, there seems to be little concrete difference between different companies, at least in the Finnish market. Making a difference could impact the company image which could also affect sales. The Responsibility Director discusses that the case company could be the one to take the first step:

> "*There is talk about accessibility and we also talk about it but in reality, we could take action and take the position [as the forerunner of accessibility]. Of course if one does it, others would follow behind but it would already be 'our thing'. ... And both customers and not-yet-customers would know that hey, this really is a responsible and caring company.*" (Responsibility Director)

POs B and C point out that prioritising backlog tickets is based on the **impact** of each action. This includes both business value and the number of current and possible future customers influenced (POs B and C). PO C notes that if a hypothetical action had an impact on only 0.25 percent of the current users of a service, that would be too small an impact, especially when there is always a backlog of tasks waiting to be performed. However, when the percentage is closer to 1.0 percent, taking an action should already be considered (PO C). Developer B finds that based on their experience, it can be difficult to estimate the business impact of accessibility.

When considering accessibility, there are a number of factors that affect implementation, among them time, money and other **resources**. PO A ponders that within two-week development cycles, it is crucially different whether a fix takes an hour or two days to complete – the former can be approved with a wave of a hand, whereas the latter already needs to be thoroughly reflected on. Nevertheless, workload estimates can be difficult to make, even if the topic was a familiar one (POs A and C). PO A explains the estimation dilemma through an example:

> "*[The designer of the team] told me last week about a ticket that [they] estimated to be a one-day ticket. And what happened was that [one of the developers] did it just like that, in less than an hour. That is a great, positive example of estimation.*" (PO A)

However, accessibility is something that teams have not actively worked on before. That increases the perceived difficulty of an accessibility-related task and possibly leads to a reluctance to even start it.

There are also known **cross-references** with other useful software project aspects from the business point-of-view. For example, SEO is known to increase website traffic through different search engines. POs A and B explain that SEO has become a topic of interest at the case company and suggest that it might be easier to introduce accessibility especially with the SEO connection.

Another factor to consider regarding accessibility is the ever-changing **legislation**. The WAD (European Union, 2016) had already been discussed in the company when its execution had become current for public sector bodies. This was due to the company's role as a major actor in Finnish society and, thus, its relatively public status. However, both interviews and observations show that knowledge regarding the existence of the EAA (European Union, 2019) was nonexistent.

The comments and thoughts regarding the upcoming legislation and its potential consequences were sparse. PO A wonders what is the compulsory minimum level of accessibility set by the legislation. Designer A emphasises that it would be good for accessibility to become compulsory and, therefore, not leave the decision making up to the certainly added business value only. Developer E thinks that enforcing accessibility legislation might be the best possible business driver due to potential fines and negative media visibility.

5.2 Challenges set by today's environment

In this section, potential and known challenges in implementing accessibility are discussed. These include both general project-related issues as well as challenges regarding technology, design and content management. Accessibility prejudices are also considered.

5.2.1 Priorities, resources and process issues

One of the biggest challenges in accessibility realisation seems to lie in **prioritisation** – there are always tasks that have higher priorities. Seven out of the sixteen interviewed team members flag this up as an issue. Backlogs are already full of these high-priority tasks (Tester A) which have proven business value. Some interviewees mention that it is the task of each PO and TPO to decide on priorities: "*Nothing is mandatory unless it comes from the business [stakeholders]*" (Tester A). POs and TPOs would need to push accessibility realisation to really support it (Designer D).

The constant state of **rush** makes it hard to even consider new initiatives like accessibility implementation improvement (Developer D; Tester B). There is little time to finetune anything, and, in the eyes of the business stakeholders, accessibility falls into that same category (Designer A). Both testers highlight that developers do not have enough time to execute any accessibility fixes. Therefore, testing accessibility feels redundant as developers would not have time to discuss or work on the arising issues (Testers A and B). Designer A notes that accessibility may be seen as "*finetuning that benefits too small a number [of people] compared to tuning the whole product*". Designer E feels that, with the exception of the designers, team members only care about accessibility if they have time around that which is dedicated to their more important tasks.

POs would be interested to learn how they could increase their **funds and resources** in order to work on accessibility improvement (POs A and C). PO C explains that "*one of the realities [of project management] is that can we find the money [to do something]*". Designer C explains that it is common to hear a PO or another business stakeholder asking how long something would take and how much money it would consume. Designer A points out that there are so many things that could be improved in any service that, with limited resources, it becomes hard to decide which one is the most important. Four members from two teams highlight that there are some big usability challenges that endanger the overall use of their service, overriding everything else as a priority.

While the interviews and observations took place, accessibility was not part of review or quality control cycle of any of the teams. Developer A explains that their team officially has an accessibility checkbox in their investigation process before a new feature is implemented, but that whether or not accessibility is really looked into depends on the investigator. Moreover, there is no

clear list regarding responsibilities or reviewing stakeholders (Tester B; Designer B) which also illustrates the sometimes missing **decision ownership** (Designers C and D).

PO C has experienced that it is **easy to forget** about good practices: "*If you do not remind people every now and then, then the more exceptional [tasks and solutions] will be easily forgotten*" (PO C). Thus, it would be crucial to remind any team frequently about upholding those good practices (PO C) until they become a habit. This also applies to accessibility and related customs. Enhancing **communication** could support these goals as well. In some teams, there is a lack of continuous conversation between team members with different roles (Designers B and D). Accessibility is not really discussed as it does not have an established role in team life and routines (Designer A; Tester A). The issue is also compounded by the difficulty of placing accessibility neatly in one designated box. Tester B has observed during their career that few people are ready to cross the line between technology and human interface and work towards a shared yet ambiguous goal.

5.2.2 Challenges set by technology

When a software has a relatively long history within the ICT industry, its team can easily be faced with **technical debt**. Six team members from two teams reference technical debt as a major issue in their continuous development work. Members of Team B ponder that some of their code is over 10 years old, and has just been built upon. Developer E ponders that balancing between multitasking and multi-optimisation can become challenging:

> "*Hard-coded [statically programmed] fixes are quick to make [on the spot]. Of course at the same time they decrease the code quality, add more code, add more future changes. Then there are more potential bugs in the code, it [static program code] increases complexity. And in that sense, it also increases technical debt. Sooner than later, we have to pay it back.*" (Developer E)

Today, **modern web technologies** are commonly used to create or update web services, to answer current needs. However, they can lead to difficulties in accessibility implementation (Developers A, B, D and E). Apparently, fixing static HTML elements and structures can be relatively easy (Designer B;

Developer D), whereas upgrading dynamic JavaScript components can become difficult (Developers B and D). Additionally, with JavaScript it is possible to assign any type of element to become an interactive one, for example a button (Developer D) which can decrease the code readability. Developer A estimates that many developers do not know what kind of HTML markup is generated out of a JavaScript based component.

A lack of knowledge combined with time constraints can lead to **code quality** issues. At first, it might be quicker to do a static fix, but in the long term, it can cause a snowball effect and lead to a proliferation of static program code that will continue lowering the code quality (Developers A and E). Developer D ponders that many developers' understanding of HTML semantics seems to be lacking altogether, making it rather impossible for teams to create valid HTML. Designer E underlines that invalid code should not be able to make it to production which alone would already improve accessible use of services. However, not all teams have designated frontend developers who would have wider knowledge and understanding about web frontend validity – changing that could already make a difference (Designer B).

Teams A and B work closely with others as their services bring together other teams and products under one service. These other teams also create program code for the software of Teams A and B. Different teams have their own ways of working as well as different styles and levels of quality regarding code (Developers D, E and F; Designers B and E). As a result, code originating from multiple different sources can cause difficulties due to varying standards and understanding.

Additionally, the age of the software appears to have an impact on the severity of accessibility issues. Developer F and Tester B point out that older software may have structural issues that affect accessibility implementation. Developer B reports that "*the worst accessibility challenges are the ones that are deeply structural, deep in the design [of the software]*".

5.2.3 Challenges related to design

The general consensus around design seems to be that designers are believed and expected to take care of accessibility due to the overlap between usability and accessibility. The designer participants themselves also appear to think that they do take accessibility into account quite well. However, the aspects of design that the designers usually talk about are mostly related to UIs or

usability of specific elements or entities on a website. Designer E describes the state of design as follows:

> "*There is enough [button] area to click, the buttons are not too close to each other, and we do not only use colour to express meaning or function. So from the design perspective, accessibility is taken into account.*" (Designer E)

The challenges identified seem to be at a **higher level** than that of smaller details. Three team member interviewees are questioning the overall consistency of the case company's products (Designers B and C; Developer A). Moreover, Designer C asks after missing design principles. Developer A points out that visual design should be unified in all services to provide a fluent user experience.

According to Designer A, designers of the company have a **wide range of responsibilities**. Although this speaks for their capabilities, it also makes decision-making harder. There are many things that could be fixed or enhanced that the designer needs to prioritise and work on in the limited time they have: "*When you have so much on your plate and only so many things that you can drive, you just have to pick your fights*" (Designer A). Designer E states that designers could also do better in their work, but does not see design work as the biggest accessibility issue. They speculate that design-related accessibility issues are often more related to high-level flows and patterns (Designer E).

5.2.4 Challenges in preparing content

In addition to the technological and design-related decisions, a digital service consists of content that finally defines the service as what it is. Regarding the content, there appear to be issues with **understandability** of services (Designers A, B and D; Senior Service Designer). Designer A analyses the current state of content creation:

> "*There are a lot of comments around [the company] that we have text professionals at marketing and communications, they are good at writing text. But what they mean is that we are good at generating a lot of text – but what about crystallising? Business people want to mention everything, but the truth is that if you bring on a million bullet points, no one will read them.*" (Designer A)

Designers B and D believe that one of the root reasons behind the understandability issues is that there is **no copywriter** at the company: "*[The company] does not have any copywriters, and it really is noticeable*" (Designer B). The design system team also brings up the lack of a designated copywriter that could support different teams with easy-to-understand content.

The **responsibility of creating content** seems to be on marketing, channel developers or designers, depending on each situation. Some designers feel like it is part of their job to go through text content from the usability point-of-view (Designers A and E). However, there are situations where the content ownership seems to be missing. For example, none of the interviewees had knowledge of whose responsibility it is to write alternative texts for images and videos. The Senior Service Designer highlights that content creation, including alternative texts, is a challenge.

5.3 Present state of accessibility

According to the team member interviews, the **first steps** towards improving accessibility have been taken in all the three teams. POs A and B report that accessibility has been acknowledged in their teams, and some initial actions have been taken to research the current state and issues related to accessibility. An evaluation of the accessibility of their services has been previously conducted by external teams (POs A and B). However, the process of accessibility evaluation has not been internalised since these experiences. Instead, other issues have been prioritised:

> "*We have not really done much about it [accessibility] but at least we have ... acknowledged this thing. But we have had challenges so significant [elsewhere] that ... we have needed to focus on these bigger challenges for now.*" (PO B)

Developers of Team A introduce that they have installed an accessibility tab into their component library tool. In that tab, some accessibility-related tests are run for each component. However, when they were asked how the team proceeds with those accessibility findings, the answer was that the results are not reviewed as a team and, thus, tackling those issues systematically is not part of their process.

Still, even with the first steps already taken, some interviewees argue that accessibility is **rarely present** in their work. Accessibility is not often discussed (Developer D; Tester B) and when it is, it is brought up by designers (PO B; Designers B, D and E). Tester B has observed that accessibility and persons with disabilities are not usually considered in commercial projects because they are a minority within masses: "*The minimum viable product is that a customer [can use] the product with normal senses and skills*" (Tester B).

Some of the current challenges are related to the ways of working of each team. Developer D thinks that the current way of working **does not support accessibility**. For example, no one provides developers with alternative texts for images, putting developers in a difficult spot (Designer E; Developer F). Designer B has provided their team with accessibility items that he has occasionally detected. However, the designer has the impression that those tasks have not been touched, leaving accessibility issues in the same state as they were before (Designer B). Additionally, there are no automated accessibility tests according to both testers and developers. Moreover, developers are not educated about accessibility matters which is visible in their actions (Tester A). PO B states that doing accessibility work and adjustments is not part of the normal workflow of their team.

Currently, it seems like most developers see a connection between usability and accessibility and, hence, assume that a majority of accessibility implementation comes from designers. All the interviewed designers have also taken the role of an accessibility advocate (Designers A, B, C, D and E) which has also been noticed by others (POs B and C; Developers A and B; Tester B). Another expected source for accessibility is the design system team (Developers A and F).

However, PO C underlines that investing in accessibility should be a team effort – a shared responsibility between all team members: "*Accessibility and other related things should be at the forefront of everyone's mind and everyone should have a shared responsibility to improve it*" (PO C). Designers agree on that, and Designer E even says that as the state of design is already quite good, the next steps of improvement should be taken in the code. Tester B also highlights the importance of teams taking an active role in the accessibility transformation. Although calling in a consultant team to "fix accessibility" sounded liberating, it would not be a sustainable solution to the overall accessibility situation (Tester B).

As the advocates of users, designers **aim to improve usability** in means

that they are given. Designers B and D feel like a professional designer with usability focus knows how to create a relatively accessible service. Some designers mention that they give feedback on the text content to help to make it as understandable for users as possible (Designers A and D). As most of the interviewed designers have experience with frontend development, they also try to help development by providing them with instructions and even example code for them to use so that accessibility or other important usability bugs could be fixed without a hassle (Designers B and E). Nevertheless, some designers feel like they need to push accessibility realisation forward quite hard to ensure that anything happens (Designers B and D).

General user testing is done once in a while, usually with the support of the customer experience team of the case company (Designer D; Developer A). However, accessibility-centred testing sessions are very rare. Designer D recalls a web accessibility session that they were able to partake with other designers of the company. They went to visit the Finnish Federation of the Visually Impaired, and had an opportunity to observe how a blind person was using some of the case company's services. Designer D emphasises that it felt "*meaningful to see what really happens [when a person with disabilities tries to use a digital service] and how many difficulties can be caused [by not implementing accessibility]*".

Designers D and E consider that **design-wise**, the state of accessibility is relatively good. Developer A tells that developers have a deep trust in the designers they work with, and that they take care of accessibility. However, some developers think that especially during the design stage of a project, something additional could be done (Developers E and F). Accessibility of the design system and pattern library is also highly trusted (Designers D and E; Developers A and F).

Some of the known **technical issues** regarding accessibility are also discussed during the interviews. Designers B and E underline that many of the UI elements cannot be reached or interacted with using a keyboard. Interestingly, Developer F reports that their team diligently keyboard tests all new UI elements before they go into production.

Members of all three teams also express that they have received **customer feedback** regarding accessibility through one channel or another. Designer B recollects that there have been inaccessibility comments from persons with visual impairments, as well as complaints about difficult understandability. Moreover, they estimate that the feedback form may be hard to use for a screen reader user, so "*if someone with visual impairments has taken their*

time to fill in [the form], that ... already tells about the level of frustration [the user has]" (Designer B). Additionally, during the observation period, a dissatisfied user posted a long comment on social media about their experiences of inaccessibility with several of the web and mobile applications that the case company offers. A product of one of the three teams in this study was also highlighted in the comment. Customer feedback has also boosted accessibility implementation in teams, at least momentarily.

5.4 Embedding accessibility

Each of the interview participants knew that the final objective of this study was to construct a way for teams and organisations to create accessible digital products and services. Therefore, they also shared their own thoughts and experiences regarding accessible design, development, and content creation and management. In this section, possibilities of embedding accessibility into an agile team environment are discussed through pre-implementation actions, agile processes, product development cycle and overall implementation.

5.4.1 Before implementation

Some interviewees highlight the importance of diligent **planning** to make any plan executable (Designer C; Tester A). Designer C asserts that attaching timeframe to an action plan helps in making that plan become reality. POs A and B as well as Tester A note that it is better to start working on accessibility as soon as possible instead of waiting for the last possible day and the EAA directive to come into force.

Moreover, ensuring the **involvement of business** from the early stage onwards can inspire teams and generally support the transformation (Designer C). Observations support that – several company employees asked during an accessibility-related conversation, "*What does business say about this*". PO A says that business stakeholders from higher abstraction levels might be more easily convinced if accessibility was discussed as their personal matter:

> "*With improved contrast differences, we can also help [you or I] sitting in the sun at the edge of the water. That is a use case I can understand: that is true, that does not sound too bad. Then we can justify that this*

> *[accessibility] is not only for visually impaired users but it might bring value to other, or even all, users.*" (PO A)

In addition, Designer C says that it could bring value and inspire the business to list examples where accessibility had a positive impact on business. Moreover, having a list of potential business risks supported by possible benefits that accessibility can cause could help business stakeholders to see the whole picture (Designer C).

A lack of knowledge was highlighted as an accessibility implementation challenge. In accordance with that, the importance of **training and education** in accessibility aspirations was mentioned by more than half of the team member interviewees (PO A; Designer C; Developers B, C, D, E and F; Tester B). Developer D notes that "*you need to make an extra effort to look for something when you do not know what you are looking for*" which may decrease the probability of taking action.

In cases of improving existing parts of a service or creating new ones, it is important to know what it is that teams are trying to take into account, and **identify existing or possible issues** (PO B). After that, those findings would need to be formulated into backlog items (PO B) that are also small enough to digest easily:

> "*The smaller pieces accessibility issues could be divided into and brought to the [Kanban] board, the more like it is that they will be done as small filler tasks, small fixes. That would probably require that there is someone who could think and chop them [tickets] into smaller pieces. I believe that we could advance accessibility that way.*" (Developer B)

PO A brings up that knowing the **priority order** within all accessibility issues is crucial for effective implementation: "*We would need some sort of approximation as to how much time and what each piece of work requires, but also what are priorities within the accessibility queue, what are quick wins and most reasonable things to do first*" (PO A). Knowing these priorities and even reasons behind the prioritisation logic could contribute to their implementation (PO A).

A DS can be a substantial support for teams during design, development and test stages of software development. Developers A, B and C state that a DS should be able to support and ensure a good starting point for accessible

development. Developer A emphasises the importance of the DS support through their own experiences:

> "*What I have learnt from before [regarding accessibility projects] is the importance of a good style guide and library as well as a design system that supports accessible development.*" (Developer A)

Developer C feels that a shared DS would be a natural outlet for any accessibility content. Moreover, it could simultaneously boost accessibility implementation: "*It [accessibility] would flow down and then, little by little, it would become part of the implementation process*" (Developer C). Common components from a design system would also require both design and development guidelines for team members to be able to use them to their full extent, especially in the beginning of the path of accessibility (Developer B). Similarly, the design system team agrees on the DS being a great place for gathering accessibility information and examples.

5.4.2 Merging into agile environment

Eight team members out of sixteen conclude that **embedding accessibility into processes** of the organisation and teams would be a good solution (PO A; Designers B, C and E; Developers B, C, E and F). Additionally, POs A, B and C as well as Designer C and Developer E think that based on their experience with either accessibility or other new initiatives, it is important to plan and implement everything to be accessible from the start instead of trying to fix the situation afterwards. Developer E argues that including accessibility is easier in new projects where accessibility can be truly considered from the start:

> "*It [accessibility implementation] is only a small effort if you think to take it into account since the beginning [of the implementation process]. Then it will not cause problems. But afterwards, it can be a huge hassle and lead to extra work.*" (Developer E)

Designer C is under the same impression: "I have learnt that it [accessibility] should be taken into account from the beginning because if you try to change afterwards, it will take so much more time" (Designer C). Developer E highlights that it is important to make accessibility part of development cycles,

for example review meetings, to ensure continuous and balanced accessibility implementation. According to Developer B, this can also make accessibility **easier to maintain** on a project level.

Developer D reasons that bringing some new habits into a team's ways of working would not lead to additional workload, especially if that change was done early on. They describe this through a design system and pattern library example from a project:

> "*Mostly, the issue was that it [use of the pattern library] did not become a habit. It would have probably been smart [to make it a habit] even though on a short term it might have brought upon some extra work. Also, if it had been part of our processes since the beginning, it [including new ways of working] would have happened almost unnoticed. Then, it would have become our way of working and it would not have added any additional work to a new feature. But now, it would be extra work for sure.*" (Developer D)

PO C brings up that **accessibility quality** should also be controlled like any other aspect of software. Moreover, its implementation should not only depend on selected individuals in a team but all the team members:

> "*Just like any quality control things, accessibility and other related aspects should be on top of everyone's mind, and everyone should have a shared responsibility to improve it [accessibility].*" (PO C)

However, practical execution is another layer on top of the ideological thought. Just like with other aspects of quality control, it raises the question of when accessibility control should take place, and how often it should be done (PO C).

Practical guidelines around implementation can also support practical doing and sustainable change. Four out of six developers have some previous project experience regarding accessibility, and are spread over all the three teams interviewed. They describe how accessibility was part of the daily and weekly processes of their projects, supporting the overall accessibility implementation. The two developers with little accessibility experience express that knowing about best practices regarding accessibility would help them to do their work more properly: "*It would be good to get some kinds*

of guidelines and lists on how to fix [accessibility issues] and lacking [development] processes" (Developer from team B). Moreover, not all services are the same and include different types of features and user flows. Developer D reflects that service-specific recommendations are also important in creating holistically accessible services. A checklist format could also make guidelines easier to approach (Designer E; Developers A, C and F).

5.4.3 Product development cycle

In the case of every team interviewed, each product was already live and being used by customers of the case company. The product of Team A was going through a redesign project while Teams B and C were both concentrating on maintaining and improving their products through smaller steps and projects. Thus, these teams have a two-part mission regarding those services: creating completely new material, and modifying and improving the already existing material.

One part of their work is creating **new material**. POs A, B and C all think that it is important to avoid anything ending up in an accessibility audit by ensuring **continuous** accessibility quality. This step is the easiest to take with new features as they have not yet been developed. Designers C and E say that increasing the amount of accessibility knowledge and making accessibility part of the implementation processes could help in creating accessible services:

> "*I think it is really good to bring in [accessibility] awareness as soon as possible ... and already put it into our implementation process, rather than later on then it [the EAA] comes. Not like what happened with the GDPR, basically.*" (Designer C)

Additionally, Developer B brings up that accessibility should be continuously maintained to keep up the quality. Thus, it would not be a sustainable solution to call in an accessibility consultant to "fix accessibility" in one go (Tester B) and then leave accessibility practices behind.

The **existing material** requires a transformation to become accessible as well. Both designers and developers discuss that running a comprehensive accessibility audit, followed by a set of all-encompassing accessibility fixes for a digital service would be a difficult solution to carry out in a project

environment (Designers B, C, D and E; Developers D and E). POs B and C ponder that it might be the most effortless way to work on accessibility fixes when a feature or element is about to be modified anyway, for example due to a bug fix or improvement. Moreover, PO A estimates that multiple small accessibility actions executed at different times are likely to be less expensive:

> "*In a way, it is my job to be the gatekeeper, to make sure that the resources are used rationally [in the project]. Whether [improving accessibility] is a full time three-month chunk or something much faster and smaller, it is a very important piece of information.*" (PO A)

Even though **audits** are not seen as the only solution for accessibility, their value may lie in the possible support they can provide. PO C says that accessibility audits could be performed now and then while, at the same time, there is an ongoing conversation related to accessibility during retrospectives and other regular interactions. This would ensure continuous feedback on accessibility development through audits as well as continuous accessible implementation:

> "*Kind of the same way we do some information security things. ... We agree that every so often we do them [audits] so that we can get feedback. These kinds of things were found in the audit. ... And then they become development items. Otherwise, these [accessibility] things do not pop into our minds, all the possible existing use cases.*" (PO C)

PO C and Designer C also ponder that it may be a good starting point to do a small, team-driven audit in the beginning of accessibility aspirations, to create a solid starting point.

5.4.4 Practical implementation

On a practical level, the interviewees tend to concentrate more on the technical aspects of accessibility implementation. All designers stressed the importance of **testing and evaluating** software regarding accessibility (Designers A, B, C, D and E). Designers C and E suggest that accessibility of web services could be easily tested to some extent by using free online tools. Designers A, D and E as well as Developer C also talk more specifically about the benefits of test automation and improving it to include accessibility:

> "*Even though we [manually] review all commits [saved project changes], it is still difficult to keep to a certain standard so that everything would always be of the same [quality]. If we had more automated tests, it [accessibility] could actually be properly supervised. ... If we could include it [accessibility] into tests, it would be easier to maintain it.*" (Developer C)

On the other hand, Developer B thinks they have never seen or heard of automated accessibility tests. Thus, it makes it hard for them to imagine a situation with the possibility of them (Developer B). Developer B also considers that making comprehensive accessibility tests might be a very difficult task.

The Senior Test Expert of the company estimates that it should not be impossible to create automated accessibility tests to a certain extent. However, they think that for the best results, it would be necessary for one team to take an active part in the test implementation process. Creating meaningful tests for accessibility would be the best solution in a real project environment because that way it is possible to find and test the real life accessibility challenges. Afterwards, those tests could be applied to other projects:

> "*In the best case, we could make the first set of automated accessibility tests, including browser-based end-to-end user tests [for one project]. Then they could be scaled to be general enough to flow down to each project.*" (Senior Test Expert)

However, the test automation expert highlights that there will always be things that an automated test cannot find. Thus, user testing sessions with real users – in the best case with experts by experience – would still be needed after the test development.

One part of accessibility evaluations is having experts by experience test services through real life use cases. Designers B and D also recount how a chance to observe an expert by experience using a digital service was both a disturbing and emotional experience for them. Designers B and D as well as Developer F think that it could be a good and meaningful experience for developers to be part of such a session, in order to put accessibility into context.

There seems to be a misunderstanding that accessibility is something that needs to be taken care of mainly by designers (Developers A, C and F).

However, there are many accessibility-related use cases that would benefit from more inclusive **program code**. Designers D and E emphasise that accessibility needs also at the code-side of each product and service should be highlighted. When discussing the connection between semantically correct HTML markup and accessibility, half of the participating developers note that developers should learn how to program proper HTML (Designers B and E; Developers A, B and C). Additionally, Developer A reflects upon the impact of modern web technologies:

> "*One of the biggest things that we [developers] should learn is to use HTML correctly, and also understand how our [modern web development framework] components convert to HTML. The developers of today are already quite far away from actual HTML which is, after all, what the users will see.*" (Developer A)

Designer B says that it would help to have at least one frontend specialist in each team instead of having only fullstack developers. They would be able to create semantic code more easily, and support other team members with their frontend code (Designer B). While some designers argue that most accessibility fixes on the code side are 'pretty simple' to do (Designers B and E), Designer D points out that many services of the company are quite old with a lot of technical debt: "*Accessibility has not been evaluated or improved before, and the application has been developer over many years – there would not be only a few small fixes, on the contrary*" (Designer D).

Developers A and E think that something additional should be done to accessibility especially during the **design** stage. However, they have no concrete ideas of what and how accessibility should be improved (Developers A and E). Still, Designers D and E consider the accessibility to be in a good place from the design perspective. Designer E also ponders the state of design from another angle:

> "*Of course designers could also do better in this [accessibility] area – always using the same patterns and flows in similar places and situations, and making sure that things that can easily benefit everyone are done well.*" (Designer E)

Moreover, the importance of an accessible **design system and pattern library** as a base for accessible design and program code in each project is

mentioned by several interviewees (Designers A, B and E; Developers A, C and D; Tester B). Additionally, the actual **content** of a service has an impact on accessibility – for example, if text content is not written in simple enough language or alternative texts for images are not given. Designers C and E say that it would be important to have clearly known responsibilities regarding content creation. Designers B and D also emphasise that a designated copywriter would be needed in order to create clear and truly informative text.

5.5 Accessibility evaluations

To gain a more holistic understanding of the state of accessibility at the case company, the three digital products and services from Teams A, B and C were evaluated. It has been found that following a set of accessibility guidelines results in finding only half of the existing accessibility issues (Power et al., 2018). Therefore, in addition to using accessibility tools that have their foundation on accessibility guidelines, a user path walkthrough using keyboard and screen reader software was conducted on each of the digital products and services. Moreover, clarity of each of the navigated web pages was visually considered. The key findings from each evaluated product can be found on Appendix D.

Although the three products all had different user objectives and core features, their accessibility issues seem to be related. It is evident that technical challenges are the most common accessibility issues discovered during these evaluations. Some of the most common technical issues include missing or duplicate H1 elements and other H element-related problems, undefined language, inconsistent navigating patterns and elements that could not be accessed using different means of navigation. Fewer design challenges were identified during the evaluations. However, a challenge that seemed to repeat across services is the inconsistency or nonexistence of element focus styles, especially when an element is not hovered using a cursor but focused in an alternate way. Moreover, text alternatives are used in nondescriptive ways and images are rarely bypassed even when they have a decorative purpose.

Based on the three accessibility evaluations, it appears that the state of accessibility in the context of the case company should be improved, especially in the case of technical implementation.

Chapter 6

Discussion

This study was conducted as a constructive case study research with a telecommunications and ICT company as the case company and context. The aim of this thesis was to understand the current state of digital accessibility from the perspective of existing digital products and services as well as digital practitioners, and to find out about current challenges and blockers in creating accessible products and services. The second aim was to identify possible factors, processes and practices that could affect digital accessibility from the perspective of development teams and organisations. Next, the results of this study are discussed and compared with previous research. Then, an accessibility improvement process based on the findings is introduced in Chapter 7.

6.1 Current state of digital accessibility

Previous studies show that the **state of digital accessibility** in 2010s is not good. A great number of studies have researched accessibility realisation in both the public (Olalere and Lazar, 2011) and private sectors (Gonçalves et al., 2013; Leitner et al., 2016; Wentz et al., 2018) as well as in a variety of fields and industries. The empirical results of this study imply the same also in the context of a Finnish telecommunications and software services company through the accessibility evaluation conducted on three websites and services.

The **understanding of practitioners** seems to depend on their personal

experiences and the *empathy link* created through those experiences. For example, if someone has a friend or family member with disabilities, or they have been able to observe an accessibility-related user testing session, they are more likely to have a deeper level of understanding. Furthermore, *existing knowledge and misconceptions* about accessibility emerged as a factor that results in accessibility biases. Most of the practitioners interviewed for this study have an understanding that digital accessibility is only about a small minority, primarily visually impaired people, and at the same time intimidating due to the concept of accessibility being hard for them to grasp. Many of them also mention how little they know about accessibility. There are practitioners who see the connection between accessibility and usability, but some are under the impression that its state is up to designers alone. On the other hand, there are designers who see the holistic value of accessibility as well as the importance of giving persons with disabilities a possibility to be part of the digital society like everyone else. Still, few think about the social responsibility aspect when it comes to accessibility implementation.

According to one study (Yesilada et al., 2015), persons with an interest in digital accessibility think that accessibility and usability are connected. Furthermore, lack of accessibility awareness and misconceptions regarding accessibility (particularly, that accessibility is only about a small minority or persons with disabilities would not use a specific product or service) have been found to impact accessibility implementation, or the lack thereof (Farrelly, 2011; Leitner et al., 2016).

Although the impact of an empathy link is not explicitly mentioned as a factor that affects practitioners' understanding, a personal connection to accessibility (Farrelly, 2011; Leitner et al., 2016) is highlighted as a matter that inspires them to drive accessibility implementation. Thus, empathetic connection to persons with disabilities and understanding the impact of accessibility in their lives seem to be connected.

There was a clear division between two thought patterns regarding the current state of accessibility. The first group agrees that accessibility is taken care of decently ("*I would say we have an MVP [minimum viable product] level of accessibility*") whereas the other thinks that there is a lot to improve ("*The accessibility [of our product] is awful*"). However, in the case of all the evaluated digital services, the state of accessibility was poor. This indicates that misconceptions of the state of accessibility and of what accessibility means exist. It does not become clear from the sample of the literature review whether these experiences and accessibility evaluation results have been

studied before, and the number of persons interviewed and web applications evaluated were limited in this study. Therefore, no definitive conclusions from this can be made.

Accessibility implementation is also seen as **challenging** due to several reasons. During the interviews, both product-specific (software architecture and program code, design, content) and contextual (team and organisational practices, priorities, resources) issues were reported. Due to the size of the organisation, program code, text and image content and other material may come from several different teams for a single digital service. Time constraints and anxiety of expected costs lead to strict prioritisation in favour of tasks with proven business value. In many cases, challenges are seen as blockers and reasons not to even consider accessibility in practice. Additionally, lack of practical knowledge and understanding of the distress and needs of users with disabilities appears to have a negative influence on practitioners' motivation to implement accessibility.

The challenges discovered by previous research are the same to some extent. For example, lack of knowledge (Farrelly, 2011; Katsanos et al., 2012; Lazar et al., 2004) and lack of understanding (Farrelly, 2011; Leitner et al., 2016) have been highlighted in some studies. The fear of initial costs (Farrelly, 2011; Leitner et al., 2016) and difficulties caused by several different sources of material (Leitner et al., 2016) have also been found.

It has also been mentioned that unclear accessibility guidelines (Farrelly, 2011; Katsanos et al., 2012) and contradictory requirements between accessibility and a company's design policy (Leitner et al., 2016) pose a challenge. These, however, were not expressed by the case study interviewees. During the accessibility evaluation, contrast issues between some of the brand colour combinations were detected. Nevertheless, once the design system team learnt about it, the process for changing some of the colours was initiated immediately. This may be because of the leader of the design system team and the company's design lead both have an active interest in improving accessibility. Moreover, few team member interviewees had more than glanced through any existing guidelines, making it unlikely that they would have faced unclarity. Table 10 collects the challenges found in both existing literature and this study.

Overall, there are similarities in the findings of the first part of this study and previous work. The strength of the empathetic link as a factor of understanding was emphasised in this study. In addition, the knowledge of potential challenges in accessibility implementation was increased, especially

regarding team and organisational practices.

6.2 Potential ways to impact accessibility

After reflecting on the current state of accessibility from the perspective of digital products and services, digital practitioners and possible challenges, it is of interest to discuss accessibility implementation possibilities in product teams and organisations. Although there seems to be little prior research on accessibility-related processes and project management (Freire et al., 2007; Leitner et al., 2016), factors that may impact accessibility implementation have been researched from the practitioner perspective. Next, motivators and enablers of accessibility implementation as well as accessibility-promoting practices are discussed.

6.2.1 Motivators

According to both literature and this study, there are several factors that could motivate practitioners and organisations to begin accessibility realisation. Although motivations have been classified in previous studies (De Andrés et al., 2010; Leitner et al., 2016), these classifications have some differences. Based on a wider sample including existing research and the analysis of this study, potential motivators for accessibility implementation appear to be of (i) *economic*, (ii) *societal*, or (iii) *professional and qualitative* in nature (Table 11).

(i) The material of this study indicates that the most important reasons for a company to consider embarking accessibility are **economic** ones. If it can be quantifiably proven that accessibility has *business value*, it will be easier for a business stakeholder to approve it (Farrelly, 2011). Hence, spreading knowledge about accessibility-related business cases could help to attract business decision makers in organisations and distribute awareness about the possibilities generated by accessibility implementation (Yesilada et al., 2015).

Previous studies have found that an accessible product or service can be used by a much wider audience, including persons with disabilities (De Andrés et al., 2010; Yesilada et al., 2015), elderly people (De Andrés et al., 2010; Yesilada et al., 2015), socially disadvantaged people (Yesilada et al., 2015)

and temporarily or situationally disabled people (De Andrés et al., 2010). Additionally, improving accessibility can attract more customers through increased search engine visibility (De Andrés et al., 2010; Leitner et al., 2016; Martínez et al., 2014; Yesilada et al., 2015). Accessibility can also improve *operational efficiency* of a company through reducing information system and customer service costs (De Andrés et al., 2010; Martínez et al., 2014) and, thus, increase the profitability of a company (Yesilada et al., 2015). Therefore, it can be said that more accessible products and services may allow organisations to reach a significant number of additional users. Moreover, accessibility can lead to increased business impact (Wentz et al., 2018) and even to increased revenue (Yesilada et al., 2015).

(ii) **Societal factors** are related legal aspects, social responsibility and user activity regarding accessibility. The empirical results of this study suggest that accessibility *legislation* might act as an important driver in accessibility implementation, especially as the EAA is about to come into force in the near future. Several studies (De Andrés et al., 2010; Olalere and Lazar, 2011; Wentz et al., 2018; Yan and Ramachandran, 2019) also highlight the increased legal activity as a potential motivation. However, some previous work (Vollenwyder et al., 2019; Yesilada et al., 2015) find that practitioners are on average neutral about the role of legislation as a driver of accessibility. Moreover, it has been argued that being aware of laws and legal aspects does not make a difference if practitioners and organisations do not have accessibility knowledge (Power et al., 2018).

Large companies have a certain *social responsibility* as significant influencers in society. Interviewees with experience on responsibility matters underlined the importance of accessibility also from the human-rights perspective. Social capital can also be turned into financial benefit as some people and organisations choose their partners partially based on values and their fulfillment as opposed to socially negative image (Leitner et al., 2016). The feeling of responsibility can drive practitioners (Farrelly, 2011; Yesilada et al., 2012) and also organisations (De Andrés et al., 2010) in their accessibility work.

In the case of frustrated customer feedback, teams of the case company seem to awaken momentarily to the current inaccessibility. However, the reality of higher priorities succeeds the feeling easily and relatively fast. Previous studies also indicate that *user proactivity* in giving honest feedback can provide a reason for practitioners to promote accessibility (Farrelly, 2011; Vollenwyder et al., 2019) whereas inactivity may create a false sense of satisfaction and impression of nonexistent accessibility needs (Farrelly, 2011). However, there

is a chance that persons with disabilities do not feel comfortable giving feedback (Farrelly, 2011) and end up deciding against a company instead (Extra Costs Commission, 2015). Thus, it would be important for practitioners to encounter persons with disabilities so that those practitioners can eventually understand the value accessibility has for persons with disabilities.

(iii) Finally, practitioners may be inspired to advance accessibility if they see it improving **product quality** and as a part of their **professional responsibility**. Today, accessible implementation is seen as a good software design and development practice, just like user-centred approach (Yesilada et al., 2015). Accessibility is also a matter of product quality (Leitner et al., 2016; Vollenwyder et al., 2019), and the technical accessibility improvement may decrease maintenance costs as the overall software quality increases (Leitner et al., 2016). The overall user experience has been reported to improve due to accessibility aspirations (Yesilada et al., 2015). Moreover, if a practitioner experiences that they, as a professional, are able to contribute to accessibility, it might motivate them in the process (Vollenwyder et al., 2019). The same professional and qualitative motivations were found both during the interviews and from previous studies.

The found motivations were similar in literature and empirical data. Operational efficiency was not brought up in the interviews. However, there appears to be new evidence that legislation has strength to push organisations to start considering accessibility. Potential business value might be one of the most important motivators in accessibility implementation, especially if it can be quantifiably proven. Moreover, as personal encounters with persons with disabilities seem to clarify practitioners' related understanding, regularising experience expert meetings could turn out to be a valuable motivator. Similarly, studies and theories on organisational change indicate that motivations have an important role in facilitating change (Burn and Robins, 2003; Burnes, 2004; Nelson, 2003; Nikitina et al., 2012) and lack of it may lead to unsuccessful change (Nelson, 2003).

6.2.2 Enablers and supporters

Different motivators might give a practitioner or an organisation the final push to see the value of accessibility in practice. To make aspirations reality, the motivation should be extended to creating a fruitful base for accessibility implementation. This may be through (i) increasing accessibility *knowledge* and (ii) *understanding*, (iii) ensuring access to the required *resources* and

(iv) *business and management involvement* in accessibility planning and implementation (Table 12).

(i) Without **knowledge** on accessibility it is difficult to start the concrete implementation process. This knowledge could entangle anything from accessibility implementation practicalities (technical, design or content-related) to the current state of accessibility. For example, if it was known that HTML markup semantics require revisiting, the next step would be to learn what it is that should be fixed. Lack of knowledge have been reported as an accessibility blocker, indicating the relevance of knowledge (Farrelly, 2011; Katsanos et al., 2012; Lazar et al., 2004). Moreover, Adams and McNicholas (2007) state that lack of knowledge is one of they key impediments in change facilitation. To support accessibility-related knowledge sharing, companies can set up management and communication tools to help transfer knowledge (Leitner et al., 2016). It was found during the interviews that design system is seen as a natural place to host this information. There is also research on different ways for teaching and learning about accessibility (Katsanos et al., 2012; Yesilada et al., 2015).

(ii) Although **understanding** the importance of accessibility can be seen primarily as a motivator, it is also essential for successful implementation. It can help practitioners to see the concrete value of accessibility and also how certain inaccessible aspects influence users with disabilities. Thus, lack of understanding may pose as an issue in accessibility ventures (Farrelly, 2011; Leitner et al., 2016).

The importance of involving experience experts (i.e. in this case persons with disabilities) in the implementation process has become evident (Ellcessor, 2010; Farrelly, 2011; Power et al., 2018). Even though implementing accessibility by using accessibility guidelines already can improve accessibility (Aizpurua et al., 2016; Power et al., 2018), it has been noted that with guidelines only approximately half of the accessibility problems can be identified (Power et al., 2018). Moreover, personal connections or encounters with persons with disabilities may strengthen the empathy link between practitioners and users and increase understanding (Farrelly, 2011; Leitner et al., 2016).

(iii) For practitioners to gain a certain level of knowledge and understanding and to be able to implement accessible products and services, **resources** are needed. These include accessibility training and education for practitioners and other company stakeholders, tools to support practical implementation and accessibility evaluation processes, and access to users with disabilities. In

addition, especially when practitioners in teams and organisations are about to begin practical accessibility implementation for the first time, or they plan to initiate a complete accessibility reparation project, extra time and money is required. It appears that lack or resources restricts change processes (Adams and McNicholas, 2007). It has been found that limited budgets and other resources (Farrelly, 2011), including management of accessibility processes (Leitner et al., 2016), may lead to practitioners postponing or even ignoring accessibility in their implementation.

(iv) Finally, **involving business and management** is crucial for successfully turning accessibility aspirations into reality. Key persons or champions leading an accessibility initiative have been found to inspire and motivate other employees in accessibility realisation (Leitner et al., 2016) and in other change processes (Burn and Robins, 2003). Managerial support of a change initiative can also be seen as a key factor of success (Burn and Robins, 2003; Nelson, 2003). Moreover, it was found during the interviews that defining the scope of accessibility in the context of a team or an organisation is helpful when planning accessibility implementation.

Compared to material on accessibility motivators, there is less data on accessibility enablers. This may be because implementing accessible products and services is still not a regular practice is software business – depending on a study, less than 30% (Katsanos et al., 2012) or even as little as 12% of evaluated websites (Leitner et al., 2016) have been deemed accessible according to the selected standards. Thus, the full extent of accessibility enablers has not yet been reported, whereas more potential motivations have already been detected.

6.2.3 Accessibility-promoting processes and practices

It seems there is little work on improving accessibility from the development process and organisational perspective. In this study, thoughts and experiences about good processes and practices were discussed based on previous accessibility-involving projects that some of the interviewees had experienced before, other user-centred ventures and project realities. The findings are divided into four categories: (i) *preparations before implementation*, (ii) *embedding accessibility into already existing processes*, (iii) *product development cycle*, and (iv) *practical implementation*.

(i) Before accessibility implementation begins, it should be planned well in the organisation. Business and management should be involved already from the planning phase onward. Moreover, practitioners and other members of the organisation should be trained in accessibility practicalities and processes. Accessibility issues of current products and services should be identified and prioritised so that fixing them can be accomplished. If an organisation utilises a design system or pattern library, it should support practitioners in accessibility by providing accessible components and perhaps even acting as a hub for accessibility knowledge.

(ii) Once a fruitful base for accessibility inclusion has been created, accessibility should be included in already existing design and development processes. By making accessibility a quality control task that is an inseparable part of review meetings, retrospectives and definition of done, accessibility implementation will become a natural part of project life. Practical accessibility guidelines could also support the embedding process.

(iii) Depending on the software project, it may focus on either creating new material, maintaining and enhancing existing material, or both. When *new material* is created, it should be made accessible from the beginning. This way, there will be no need to return to any newly created feature or element and reimplement it to be accessible. However, the already *existing material* requires accessibility transformation. It might be the most effortless to work on accessibility fixes every time when a feature or element is going to be revisited anyway. Accessibility audits may provide a way to gather information about the current challenges but it could be difficult to launch a project to comprehensively fix the existing accessibility issues.

(iv) It is important to *test and evaluate* accessibility continuously both manually and using evaluation tools to ensure accessibility quality. Involving experience experts in the evaluation process can amplify the potential impact of evaluation. Accessibility should also be paid attention to during the *implementation* of design, program code and product content. Again, an accessible design system and pattern library can support the implementation work.

One of the outcomes of this study is the accessibility improvement process that has been constructed based on the interview and observation results as well as the literature review. The process in its entirety will be introduced in Chapter 7.

6.3 Evaluation of the study

This work has collected existing research on the current state of accessibility of digital products and services in one place. Additionally, research material related to practitioners' experiences and thoughts regarding accessibility were reviewed. The findings on the reviewed papers were supported by empirical data gathered on the field, creating a solid ground for the second part of the research.

Based on the aforementioned material, an accessibility improvement process was implemented and process influencing factors were identified. Finally, first steps to evaluate the process and practices were taken. As a result, although the process and practices could not be fully evaluated due to time constraints of this thesis, the foundation for future research has been laid down.

Data and method triangulation were used in the empirical portion of this study to enhance the validity of the research. The results reflect the findings of previous studies which helps confirm and support some of the conclusions. In addition, different models were used together with the empirical findings as a base for the process.

This study has lead to the following theoretical contributions:

- The current state of accessibility as well as the related beliefs of practitioners have been depicted using both existing literature and empirical data.
- Factors that motivate and enable accessibility implementation have been gathered in one place based on existing research and the findings of this study. Motivators and enablers can be used by researchers in the future, creating a fruitful base for further research on accessibility implementation.
- A findings-based accessibility improvement process has been provided, and the first steps of the process have been initially evaluated with positive results.

The practical contributions of this study are within the aforementioned process. This work provides organisations and teams with a starting point for their internal work towards improving accessibility. Its value lies in its sustainability as it fits on top of any given agile framework a team may use to manage their project. Moreover, researched financial benefits of accessibility implementation have been collected in one place for organisations to reference.

6.4 Limitations of the study

This thesis was conducted as an embedded single-case study which impacts the possibilities of extending the findings to other organisations and areas of work that struggle with accessibility implementation. Nevertheless, the embedded nature of the study ensured that multiple, fairly independent teams were part of the research process which indicates the applicability of the findings to some extent. Furthermore, the results of this study present similarities with other academic studies, which suggests that the findings and, thus, the process could be adapted to other software teams and organisations.

Case studies have a qualitative nature, making it difficult to objectively judge the collected data (Yin, 2018). In this study, all the interviews and observations were conducted by the same researcher. Thus, the way in which the researcher led the conversations and posed the interview questions may have had an unintended impact on the findings, despite the researcher's aim for neutrality. Moreover, the participants were aware of the role of the researcher and the focus of the study. These factors may have led to reflexivity in which a participant might have said something to appear more virtuous or what they thought the researcher wanted to hear (Yin, 2018).

Due to time constraints of this study, the number of persons interviewed and teams visited within the case company were limited. The same challenge affected the number of papers that could be screened and reviewed for the literature review which is why some relevant articles may have been overlooked. There are also limits to the analysis process. Although the codes and categories used in the analysis were based on the research data, it was up to the researcher to identify relevant content from the data, which may also have affected the perceived findings. In addition, only some of the first steps of the accessibility improvement process could be tested. Although the initial evaluation results of the process so far seem promising, the entire process cycle needs to be evaluated before any further conclusions can be made.

Challenges	Literature	Empiricism
Knowledge and understanding	Lack of knowledge (Farrelly, 2011; Katsanos et al., 2012; Lazar et al., 2004)	Lack of knowledge
	Lack of understanding (Farrelly, 2011; Leitner et al., 2016)	Lack of understanding
Resources and prioritisation	Initial costs (Farrelly, 2011; Leitner et al., 2016)	Expected costs and expenses
	-	Time constraints
	-	Higher priorities with proven business impact
Material	Unclear guidelines (Farrelly, 2011; Katsanos et al., 2012)	-
	Contradictory design requirements (Leitner et al., 2016)	-
	Difficulty of quality assurance when material comes from several different sources (Leitner et al., 2016)	Material (e.g. code, content, UI elements) comes from several different sources
	-	Technical challenges (e.g. technical debt, modern web technologies, invalid HTML markup)
Practices	-	Practices do not support accessibility implementation
	-	Forgetting about good practices
	-	Designers have a wide range of responsibilities
	-	Content creation (e.g. no copywriters, multiple creators)

Table 10: Experienced challenges in accessibility implementation.

Motivators	Literature	Empiricism
Economic value	Business value (De Andrés et al., 2010; Farrelly, 2011; Leitner et al., 2016; Martínez et al., 2014; Stephanidis, 2001; Wentz et al., 2018; Yesilada et al., 2015)	Business value and risks
	Operational efficiency (Martínez et al., 2014; Yesilada et al., 2015)	-
Societal factors	Legislation and other legal activity (De Andrés et al., 2010; Olalere and Lazar, 2011; Power et al., 2018; Wentz et al., 2018; Yan and Ramachandran, 2019)	Legislation (WAD and EAA)
	Understanding the importance through user activity (Farrelly, 2011; Vollenwyder et al., 2019)	Understanding the importance through user activity (feedback and social media) and personal encounters
	Social responsibility (De Andrés et al., 2010; Yesilada et al., 2012; Farrelly, 2011; Leitner et al., 2016)	Social responsibility (human rights)
Professionality and quality	Improving the overall UX (Yesilada et al., 2015)	Improving the overall UX
	Software quality (Vollenwyder et al., 2019; Leitner et al., 2016)	Software quality
	Part of good software design and development practices (Yesilada et al., 2015)	Part of good practices
	Practitioner's self-perception as a specialist (Vollenwyder et al., 2019)	Designer's self-perception as a specialist

Table 11: Motivators for practitioners and organisations to improve accessibility.

Enablers	Literature	Empiricism
Knowledge	Knowledge (Katsanos et al., 2012; Leitner et al., 2016; Yesilada et al., 2015) or the lack thereof as a blocker (Farrelly, 2011; Katsanos et al., 2012; Lazar et al., 2004) in accessibility and other change projects (Adams and McNicholas, 2007)	Knowledge (e.g. accessibility implementation, HTML markup semantics)
Understanding	Understanding or the lack thereof as a blocker (Farrelly, 2011; Leitner et al., 2016)	Understanding (e.g. how accessibility in fact impacts people's lives)
	Experience experts (Farrelly, 2011; Power et al., 2018)	Experience experts (how accessibility in fact impacts people's lives)
	Personal connection (Farrelly, 2011; Leitner et al., 2016)	Personal and empathetic connection
Resources	Resources or the lack thereof as a blocker (Farrelly, 2011; Leitner et al., 2016) in accessibility and other change projects (Adams and McNicholas, 2007)	Resources (education, tools, access to users, time, funds)
Business and management involvement	Key persons, project champions and leadership (Leitner et al., 2016) in accessibility and other change projects (Burn and Robins, 2003) or lack thereof as a blocker (Nelson, 2003)	Leadership, ownership and responsibility
	Managerial support in other change projects (Burn and Robins, 2003)	Managerial support
	-	Defining the scope of accessibility

Table 12: Enablers for practitioners and organisations to improve accessibility.

Chapter 7

Accessibility Implications

Based on the results collected in the previous chapter, practices and processes for improving accessibility are presented here. First, the *Accessibility Maturity Model* for measuring accessibility maturity of an organisation is introduced. Then, the *Accessibility Improvement Process* for improving accessibility maturity from some knowledge to repeatable and established ways of working is proposed. Lastly, the initial results of the testing of the first steps of the process are presented.

7.1 Measuring accessibility maturity

The Capability Maturity Model (CMM) can be used as a tool to adapt for different aspects of software development projects. Within accessibility, it has also been used as a base for some industry-drawn frameworks [1]. However, a multitude of adaptations of the CMM blueprint are unthinking, and there is limited guidance on specific steps that should be taken in order to move from one maturity level to another (Röglinger et al., 2012). Furthermore, no previous research on adjusting the CMM or other maturity models for accessibility purposes and using it to support accessibility processes has been found.

[1] See e.g. Digital Accessibility Maturity Model: `https://www.levelaccess.com/the-digital-accessibility-maturity-model-introduction-to-damm/` [Accessed: 28/6/2019].

Moreover, accessibility is a usability-related aspect. Therefore, applying the Usability Maturity Model (UMM) and Human-Centredness Scale (HCS) to accessibility maturity evaluation would be a natural option. As a result, all three models have been used to form an Accessibility Maturity Model introduced next.

A maturity model measuring accessibility processes of a team or an organisation can be a useful tool in estimating what actions should be taken to gradually improve the state of accessibility based on a chosen scale. The Accessibility Maturity Model is a six-step model for web accessibility maturity. Instead of looking at a software process on a macro scale, it narrows the focus down to accessibility. As it is possible to run a software project without considering accessibility, the model starts from level 0. The levels are described below.

Level 0: Unconsidered

Accessibility is not considered at the team or organisational level. This can be due to uncertainty of accessibility needs or processes in general, or a nonchalant attitude. However, it is possible that attitude towards accessibility on an ideological level is positive.

Level 1: Initial

Accessibility activities and processes are in the hands of individual practitioners who see the criticality of accessibility. As there is no team or organisational support dedicated to accessibility, activities and processes are unpredictable, *ad hoc* and in a state of continuous change. Only some individual parts of products and services may be accessible.

Level 2: Repeatable

Some accessibility processes are repeatable at the team level and they can provide consistent results. Accessibility implementation is supported on a small scale in some teams. These processes have become easy to maintain within the practitioners who work with accessibility – even during stressful periods. Practitioners are growingly aware of the importance of accessibility.

Level 3: Established

An accessibility standard has been defined and documented for an organisation, and the processes supporting the implementation are used across the organisation. Moreover, resources for accessibility implementation have been defined. Accessibility processes are managed and controlled within both teams and their home organisation. All newly created material is accessible from the beginning.

Level 4: Implemented

Accessibility processes have become part of both organisational and development team routines. A certain level of accessibility has been reached within existing products and services. In addition, accessibility processes have become somewhat predictable and routine.

Level 5: Optimising

The organisation is confident with its accessibility processes and seeks to continuously improve and optimise the existing processes and practices (technical implementation, design, content). Accessibility has become an inseparable part of the organisational culture.

In this model, the accessibility maturity of an organisation can be measured through the state of accessibility processes on both team and organisational level. However, it should not act as a standalone concept but as a tool to evaluate how the steps taken in order to improve accessibility have impacted the teams and their home organisation. Therefore, these steps should be determined in order to utilise the Accessibility Maturity Model properly.

7.2 Accessibility embedded process and improvement steps

When accessibility is not originally considered in a project environment (level 0), the slightest initial steps of improvement can already raise the maturity

to the next level (level 1). However, making accessibility processes repeatable in a team context (level 2) and later in the whole organisation (level 3) requires consistency and commitment from different parts of the organisation. With time and experience, it is possible for an organisation to become attached to accessibility processes on a managerial level (level 4) and, finally, to start developing and improving accessibility processes proactively within the organisation (level 5).

In this study, the transformation from initial accessibility actions to repeatable and organisationally defined accessibility processes are looked into (the steps between the Accessibility Maturity Model levels 1, 2 and 3). Although accessibility has become a current topic in the eyes of the public and decision makers, there are few organisations that have already matured to the defined level. Thus, developing accessibility processes to a level that is both repeatable and defined is the first objective for sustainable accessibility realisation.

The case interviews and observations demonstrated that business representatives are worried about the time and money that a complete accessibility audit and reparation project might require. Therefore, instead of a holistic accessibility audit for each digital service of an organisation followed by immediate and all-encompassing fixes as the solution, I recommend a *twofold process approach* over a longer period of time. After an organisation has found its *motivation* for accessibility implementation and the *enablers* for continuous accessibility have been ensured (Figures 6 and 7), the process is divided between creating completely *new material* and revisiting already *existing material*, keeping usable accessibility as one of the quality metrics for creation. Figure 8 presents the process cycle in a simplified manner.

It is important to note that what works for one team or organisation might not work well in other contexts. For instance, some teams or practitioners may find checklists beneficial ("*It would be great to have an accessibility checklist to follow*") while others do not utilise even the existing checklists ("*We have a definition of done checklist but no one ever refers to it*"). Therefore, it may be advantageous to apply different methods to accessibility aspirations.

7.2.1 Motivators and enablers in accessibility transformation

Before a practitioner, team or organisation can start creating accessible solutions, there are certain factors that can enable the transformation. However, even before that, a certain level of motivation is required so that both practitioners and organisations may become enthusiastic about accessibility realisation.

The recognised **motivator** types are:

- *Economic* factors (business value, operational efficiency);
- *Societal* factors (legal aspects, social responsibility, user activity); and
- *Professional and qualitative* factors (product quality, professional responsibility).

Figure 6: Accessibility implementation influencing motivators.

It is important to convince the business and management of a company to support the accessibility initiative. This is likely to happen through highlighting the economic impact that accessibility may lead to. Therefore, informing them about the business value and operational efficiency that accessibility can bring may be beneficial. Additionally, if there are legal restrictions, it may be useful to underline the risk of sanctions and potential negative image. Giving users with disabilities opportunities to show how inaccessibility constrains their lives, for example by inviting them to visit different teams, could deepen their understanding of the need for accessibility. Product quality and satisfied users could also be sources of professional pride and appealing to them may inspire practitioners to consider accessibility.

The identified **enablers** are:

- *Knowledge* on accessibility implementation;
- *Understanding* the need for accessibility and what are potential accessibility challenges;

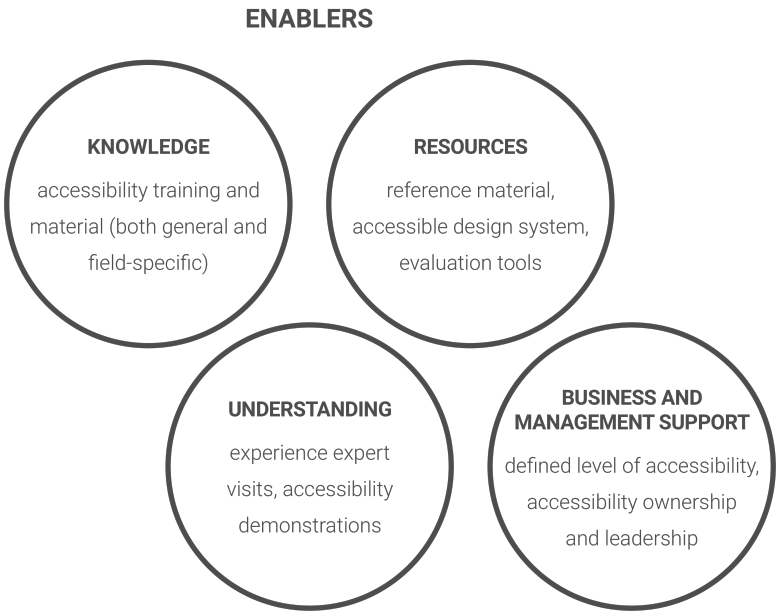

Figure 7: Accessibility implementation influencing enablers.

- *Resources* for accessibility implementation and evaluation, including access to tools and experience experts but also time and financial support, especially in the beginning of the transformation; and
- *Business and management support* that makes both the overall management and possibility to use resources easier.

There are several ways to approach the aforementioned enablers. Next, some suggestions for enabling accessibility are introduced.

- Knowledge: general training session with focus on digital accessibility and its impact in general; specified training sessions for practitioners on how they can impact on accessibility; training material in an easily understandable format and with practical examples; online accessibility tutorial videos and articles as a low-key starting point.
- Understanding: product-specific accessibility demonstration session with an accessibility expert for the whole team; experience expert visit with a demonstrated use case experiment.
- Resources: reference material in a centralised location; a list of recommended tools for accessibility implementation; access to accessibility tools (free, paid or both); accessible design system and pattern library (if applicable).
- Business and management support: setting up common accessibility standards for the organisation (e.g. based on WCAG 2.1, the EAA or both); ensuring ownership on accessibility transformation; ensuring access to required resources; encouraging accessibility-promoting practices in daily project work; demand for accessible production towards teams.

7.2.2 Accessibility process cycle

In the case of existing digital products, the state of accessibility should be **evaluated** in order for a team or organisation to know how they are performing with regards to accessibility implementation. Similarly, an evaluation should be conducted at the end of the iteration cycle in case of every new digital product or service. User-driven evaluation patterns have been suggested by several studies (Sato et al., 2010; Power et al., 2018). Additionally, Gonçalves et al. (2018) reflect that conducting complete accessibility and usability testing can be "*enriching because it allows for the extending of knowledge to the real state of the platform and the real needs of the participants*". It has been highlighted that one implementation-related challenge is

accessibility quality assurance as it can be difficult to double-check every element on a website, especially when the website is large and there are several content creators (Leitner et al., 2016). Therefore, combining semi-automatic or automatic test tools with user testing could give the evaluation process strength to check for many of the frequently repeating technical accessibility issues.

Based on the evaluation, the accessibility issues found in existing products and services should be incorporated into an **action plan**. On the other hand, in the case of new products or features it is essential to make sure that the initial planning already takes accessibility into consideration. The level of planning may be different depending on for instance the organisation's accessibility criteria and existing or upcoming legislation.

Finally, accessible features or elements should be **implemented** for better accessibility. It has been found that most of the identified accessibility issues are technical (Leitner et al., 2016). Therefore, emphasis on technical imple-

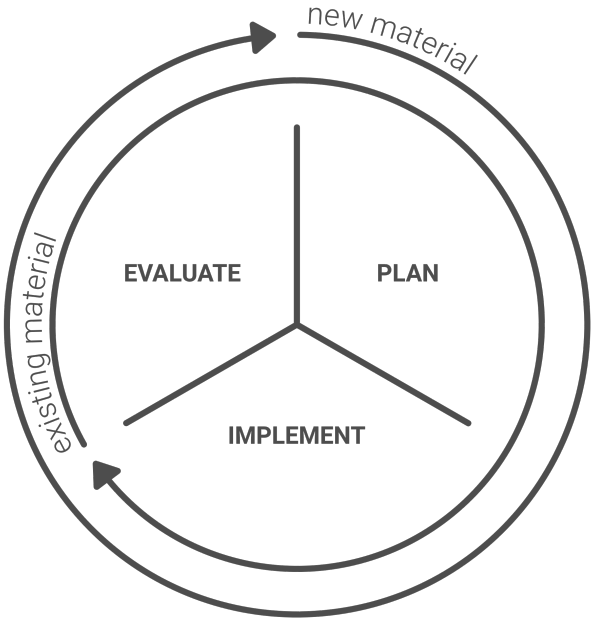

Figure 8: Accessibility practices as a part of product design and development process.

mentation should be expected. Sato et al. (2010) found that almost half of the accessibility problems reported by users were resolved within 24 hours, which indicates that many of the reported issues may have been relatively small fixes for them to be solved in a short period of time. The empirical results of this study support the aforementioned findings. Including accessibility promoting processes in the regular software development cycle (regular project meetings, definition of done) can support accessibility efforts in becoming a seamless part of regular development processes in the future.

To ensure the sustainable continuation of accessibility implementation, it is important to make accessibility implementation part of daily development, design and content creation practices. Next, some ideas for project immersion are proposed:

- Incorporating accessibility into each team's work life (e.g. retrospectives, sprint reviews);
- Making accessibility control part of code and general quality control and part of the definition of 'done';
- Using checklists as a support tool in accessibility implementation;
- Different ways to evaluate accessibility: continuous accessibility evaluation as a part of the development cycle, whether manual (using a keyboard or screen reader) or using tools (e.g. Wave, Axe, Lighthouse); experience expert evaluation sessions once in a while;
- Involving the whole team in accessibility evaluation sessions for everyone to see how their work can impact accessibility;
- Prioritising identified accessibility issues based on their criticality (the most critical ones prevent accomplishing the key user flows) and working on them according to the criticality level.

7.2.3 About the construction

The Accessibility Improvement Process introduced above has been mainly constructed based on the research data gathered during this research. However, other material related to for example change facilitation and implementation has been used to support the creation process. This contributes to the quality of the initial process prior to a complete evaluation and iteration of the process.

The 3-step model states that it is crucial to first unfreeze the organisational setting and create a fruitful ground for change through different motivations (Burnes, 2004). Other studies (Burn and Robins, 2003; Nelson, 2003; Nikitina et al., 2012) also indicate that a motivation of some sort or motivating leaders may be behind a successful change process. Similarly, the accessibility improvement process also starts by creating a motivational ground.

The rest of the process focuses on supporting team members and organisations in embedding accessibility practices into their daily work lives. At first, a wider transformation of small changes all over the organisation and team processes is required so that accessibility can truly be attached to the regular team practices and processes. After that, it is necessary to continue to keep accessibility as a part of team and organisational practices to ensure the continuation of accessibility. Again, this ideology has its similarities to the 3-step model (Burnes, 2004).

However, it is also crucial to consider the dynamic nature of change. Each event in the change process modifies the change context (Nelson, 2003). Moreover, the surroundings of the system may also change which should be taken into account when implementing change (Nelson, 2003). Therefore, an iterative and responsive mindset in applying this process is highly recommended.

The findings of this study go hand-in-hand with the expanded web accessibility integration model (Farrelly, 2011). Societal foundations and stakeholder perceptions have been taken into account as the foundations for motivators and different natures of web development in the iterative process cycle. The utilisation of tools and resources as well as end users has been recommended to ensure the level of accessibility that is aimed for.

The accessibility process cycle can be seen as a specialised iteration of the PDCA cycle (see Moen and Norman, 2009). However, one step has been dropped out of the cycle due to different nature of the process. Instead of creating a prototype during the first three steps that could be acted upon during the fourth step, the aim is to continuously improve the accessibility of a product or service. If the evaluation results indicate that another round of planning, implementing and testing is needed, the earlier version will be in use until the next, more accessible version is out.

7.3 Evaluating the effect of the process

Some of the first accessibility-promoting actions based on the Accessibility Improvement Process were executed and evaluated at the case company. More specifically, the following two actions were taken:

1. Four accessibility evaluation sessions (one-on-one) with designers to evaluate the accessibility of a selected user flow and introduce and test free accessibility evaluation tools;
2. Two accessibility information and demonstration sessions with an entire team.

Next, the sessions are described in more detail and the indications of their performances are presented.

7.3.1 Accessibility evaluation sessions

Due to the strong ownership designers seemed to have for accessibility, four accessibility evaluation sessions with designers were conducted. Each session was followed by a short email interview. For the sake of referencing findings from sessions and interviews, each participant is identified as Designer W, X, Y or Z.

Already before the evaluation session started, all designers expected that their services were inaccessible. Designer Z had an understanding of the current state due to an accessibility evaluation conducted earlier that year whereas Designers W, X and Y only had a hunch based on their own initial evaluation experiments and customer feedback. For instance, Designer X notes that they "*expected that the [digital service] is mostly inaccessible", and that "the evaluation supported my views*". Designer Y states that they were "*disappointed with the state of frontend code, [my] expectations were higher with [HTML] semantics*".

Although the participants were disappointed at the current state of accessibility, most of them were able to start considering future steps for improving accessibility (Designers W, X and Z). Designer X sees that little changes could make a reasonable difference, whereas Designer W ponders that there is a need for structural long-term changes. However, Designer Y seems to

be worried about the future of accessibility: "*I fear that [accessibility implementation] will still be trampled by everything else*" (Designer Y).

All designers were pleased with the evaluation session and the evaluation process and tools introduced to them. Designer W explains that "*the evaluation clarified the picture [of accessibility] and gave an understanding of how accessibility could be systematically improved and embedded into software development processes*". Designer X was happy to notice that many of the current accessibility issues are reasonably easy to fix: "*[Accessibility implementation] would be mainly about small changes into daily work*" (Designer X). Designers Y and Z underline that having the opportunity and a reserved timeslot to learn how to use different tools was especially useful. Moreover, Designer Y notes that they had been too intimidated to try a screen reader before. The participants agree that they were able to gain valuable information about accessibility, evaluation possibilities and even implementation.

The introduced methods and tools are also seen as something that could be easily incorporated into future design work. This is highlighted by all the designer participants. In addition, the designers are all ready to recommend a similar accessibility evaluation session to their colleagues. Three of the designers mention that not only designers could benefit from accessibility evaluation knowledge, but also developers (Designers W, X and Z). This is evident for example in the following sentence: "*Probably even more important target group than designers would be frontend developers whose choices have a huge impact on accessibility*" (Designer W). Designer Z emphasises that the session was "*extremely practical and concrete . . . now I know which tools to use and what kind of [accessibility improvement] process could work*".

It appears that there is a strong sentiment that improving accessibility should not be the sole responsibility of designers. For instance, Designer Z expresses that accessibility implementation "*should be about us sparring with each other, not only a designer's responsibility*". In addition, Designer W considers that it is important to work towards increasing accessibility knowledge, because accessibility "*is a quality factor that common technology practitioners will not notice*" (Designer W). All the designers found the evaluation sessions helpful and informative which also supports the view that accessibility knowledge should be increased.

Based on these results, it can be said that the evaluation sessions were successful in widening both understanding and knowledge base regarding accessibility. Moreover, especially the designers seemed to be inspired to begin to work on accessibility. However, it remains to be seen whether these sessions

were enough to start a more comprehensive accessibility movement within the organisation.

7.3.2 Accessibility training and demonstration sessions

Out of the three teams observed and interviewed, Teams A and B participated in the initial accessibility training and demonstration sessions. Most of the team members of both teams were able to join their corresponding sessions. Although the team members were encouraged to ask questions and comment on the topics discussed, there was little conversation during the session. During the presentation of different motivational factors, there were a few questions inquiring some more details which indicates that the motivators drew some attention.

During the demonstration, however, the room seemed to stir in both sessions. Most of the team members showed signs of disbelief and shock, especially during keyboard and screen reader navigation. This became apparent when many of them started shaking their heads, whispering or even laughing when they were presented accessibility issues that complicate or completely block some of the core features of their service. There were no comments regarding the process suggestion during the sessions. This may have been because of the demonstrations as they might have been still on participants' minds.

After the sessions, altogether five members from Teams A and B came to express how the session had been eye-opening. Moreover, a designer from one of the teams comments that the accessibility session was extremely useful. According to them, "*all the developers were facepalming when they learnt about the state of accessibility – now we hopefully can do something about this!*" However, not all team members feel positively about accessibility implementation due to time it may consume. One of the business stakeholders considers that some services are more important to become accessible than others, and those are the ones that the accessibility improvement initiative should start from.

Similar to the accessibility evaluation sessions, the accessibility training and demonstration sessions seemed to increase motivation, knowledge and understanding of the team members. Moreover, it was possible to reach a wider audience with the team sessions compared to the designer-only sessions. Nevertheless, there are still team members that are sceptical about accessibility

implementation. Thus, the accessibility promotion work should be continued and business involvement should be assured to support accessibility work.

During the observation period, it was also possible to implement some initial accessibility-related fixes on the digital product of Team B. The changes took place after the accessibility evaluation and the following accessibility task prioritisation. It was found that most of the listed accessibility tasks were estimated to be "quick fixes" by developers. Moreover, the fixes were often implemented even faster than it was originally estimated. As a result, the attitude towards future accessibility tasks became relatively positive. This also indicates that many of the technical accessibility fixes may be relatively quick fixes.

Chapter 8

Conclusions and Recommendations

The aim of this thesis was to define processes and practices that may promote accessibility realisation in agile software development. The research aim was approached with the following research questions:

RQ1: How is digital accessibility achieved today...

(i) ... from the perspective of digital products and services?

(ii) ... from the perspective of digital practitioners (understanding, consideration, perceived challenges)?

RQ2: What factors may motivate and enable accessibility realisation?

Based on the previous chapters, answers to the research questions are proposed next. Then, the Accessibility Improvement Process is presented. Finally, implications for future study are discussed.

8.1 Answers to the research questions

The research problem of this study was to find out about future possibilities regarding accessibility implementation, and collect and construct factors, practices and processes that could lead to an improved state of accessibility.

To approach the problem, it was essential to create an understanding about the current state of accessibility from different viewpoints: actual products and services, practitioners that produce them as well as observed challenges in their work environment. This happened through RQ1.

> **RQ1**: How is digital accessibility achieved today...
>
> (i) ... from the perspective of digital products and services?
>
> (ii) ... from the perspective of digital practitioners (understanding, consideration, perceived challenges)?

First, accessibility realisation in digital products and services was considered by looking into recent studies on accessibility realisation. The literature review brought up that inaccessibility is still a major issue in 2010s. There are standards and guidelines that can support digital practitioners in their implementation work but, by using them alone, only half or so of the actual accessibility issues can be found and fixed. In addition, they are often hard to understand and apply in a real-world context.

The results from the literature review were supported by a user-centric expert evaluation on three digital services of the case company. The evaluations were conducted on a self-service platform, an e-commerce website, and a video streaming service. WCAG 2.1 was used as the base for the evaluation and combined with demonstrated user scenarios using keyboard and screen reader navigation. The results of the evaluation are similar to the previous work and underline the poor accessibility of digital products and services.

Overall, all the participants had a positive attitude towards accessibility, even if they did not have a decent understanding of accessibility. Similarly, the literature review indicates a generally positive attitude towards accessibility. However, there was a clear difference between participants who have an empathetic link to people with disabilities in the digital context, and others who had a theoretical understanding of accessibility needs. Depending on the depth of their empathetic link, the level of consideration also varied. Moreover, misconceptions of the state of accessibility exist especially within developers as many of them believe their digital services are not particularly inaccessible.

Designers feel a strong ownership of everything user-related, including accessibility. However, due to a wide range of responsibilities and lack of resources, some of them find it difficult to incorporate accessibility into their

work. In general, practitioners find that there are product-specific and contextual challenges as well as knowledge, time and financial constraints that complicate the realisation of accessibility implementation. Moreover, lack of understanding seems to be a remarkable challenge.

Next, the basis for accessibility implementation in team and organisational context was researched through RQ2:

> **RQ2**: What factors may motivate and enable accessibility realisation?

The identified motivators are one of economic, societal, or professional and qualitative in nature. It appears that according to this research, economic reasons are the most important at the organisational level due to potential financial benefits. However, societal reasons such as legislation and social responsibility act as important drivers as well. Professional aspects, including product quality and specialist responsibility, may affect the motivation of individual practitioners.

At the start, accessibility implementation may be enabled through increasing accessibility-related knowledge and understanding, ensuring access to resources and business and management involvement. Additional knowledge may, for instance, be related to technical implementation, design preferences or the overall benefits of accessibility. Understanding may be enhanced by encountering persons with disabilities and exploring how they would use a digital product or service. Business and managerial support as well as resources can make the beginning of the accessibility transformation easier as practitioners are not required to be in charge of the process themselves.

8.2 Accessibility improvement process

As mentioned earlier, the ultimate aim of this thesis was to define processes and practices that may promote accessibility realisation in agile software development. Based on the answers to the research questions, the following activities are recommended:

- Creating a motivated atmosphere for accessibility implementation;
- Ensuring that an accessibility implementation initiative has business and managerial support, practitioners are supported to increase their level of

accessibility knowledge and understanding, and practitioners have access to required accessibility resources;

- Embedding accessibility into each team's product development processes by making accessibility an inseparable part of project life, and prioritising existing accessibility problems to ensure that the most critical issues are tackled first;
- Iterating accessibility quality through a continuous cycle of evaluating, planning and implementing in both cases of existing and new products and features.

8.3 Recommendations for future study

This study gives the first indications of possibilities of the Accessibility Improvement Process within the ICT industry, more specifically in the telecommunications, e-commerce and audiovisual media. However, due to time constraints, it was not intended to fully test the introduced process and practices. The first steps of the process were tested with the case company teams, providing an initial indication of the possibilities of the Accessibility Improvement Process.

Further examination of how the process and change is experienced within software development teams and organisations – and whether they are able to pull through the change with the support of the new process and create a sustainable state of accessibility implementation – is required for further conclusions. This study was conducted as a combination of case-study research, intended to form an understanding of the current state of accessibility and factors that motivate and enable accessibility implementation, and constructive research focused on forming a process to support accessibility implementation in teams and organisations. However, the researcher suggests that further research is conducted as action research. With an action research approach, the initial accessibility improvement process could be iterated based on challenges in the process that may be identified during its execution (Burnes, 2004).

Additionally, although the current state of accessibility was glimpsed through expert evaluations in this study, it would be of additional value to bring in experienced experts to test a digital product or service once the process implementation is about to start. This way, by bringing experience experts in also later on during the process, it would be possible to evaluate the

success of the accessibility initiative on the go from the user and software point-of-view (before-after setting).

It was noted that although findings about accessibility enabling factors exist, there seems to be less knowledge about enablers than motivators. This may be due to prevalent accessibility immaturity. Future research could focus on identifying other possible enablers which could also be used to improve the process, particularly when there are more organisations that have reached higher levels of accessibility maturity.

Once more comprehensive results on implementing the process have been found within a similar ICT and software services organisation to the case company of this study, it would be valuable to investigate whether a similar approach would work in other sectors. Moreover, using similar organisations to increase the sample could strengthen the value of the conclusions drawn here. Either way, a qualitative approach for further research is suggested for in-depth findings.

The focus of this study is the transformation between levels 1, 2 and 3 of the accessibility maturity model. Once a stronger foundation of accessibility implementing organisations exists, it would be interesting to explore the ascension to levels 4 and 5. However, that is something for the future, when the overall accessibility maturity of the world has taken a step forward.

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Appendix A

Accessibility legislation

This appendix collects different equality and accessibility legislation around the world in once place. The words *public* and *private* are used to describe the bodies impacted by the law or legal standard in question. Public refers to governmental or other public sector bodies whereas private refers to private sector companies and other bodies. If not specified, the law requires action from both public and private sector entities within the scope of the law.

Countries and unions	**Equality, non-discrimination and accessibility legislation (laws and legal standards)** (* = related to digital accessibility)	**Concrete criteria on digital accessibility** (x = WCAG, o = derivative or other)
Europe		
Austria (EU)	E-Government Act (2004)*	-
Denmark (EU)	Agreement on the use of open standards for software in public sector (2007 - public)*	x
European Union	EU directive on the accessibility of the websites and mobile applications of public sector bodies (2016 - public)*; European Accessibility Act (2019)*	x, o
Finland (EU)	Constitution of Finland (1999); Act on Electronic Services and Communication (2003, last amended 2019 - public); Law on Offering Digital Services (EU-based national legislation 2019 - public)*	x

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France (EU)	Law 2005-102, articles 47 and 78 (2005, last amended 2009 - public)*	-
Germany (EU)	Act of Equal Opportunities for Disabled Persons (2002 - public); Federal Ordinance on Barrier-Free Information Technology (2011 - public)*	x
Ireland (EU)	Equal Status Acts (2000-2004)*; Disability Act (2005 - public)	x
Italy (EU)	Stanca Act: Provisions to support the access to information technologies for the disabled (2004, last amended 2013 - public)*	x
Sweden (EU)	Discrimination act (2008)	-
Switzerland	Elimination of Inequalities for Persons with Disabilities (2002)*	x
United Kingdom (EU)	Disability Discrimination Act (1995); Equality Act (2010)*; Public Sector Bodies Accessibility Regulations (EU-based national legislation 2018 - public)*	x
North America		
Canada	Canadian Human Rights Act (1985); Standard on WA (2011, last amended 2013 - public)*; Accessible Canada Act (ACA) (2019 - public)*	x
United States	Section 504 of the Rehabilitation Act (1973 - public); Section 508 of the Rehabilitation Act (1986, amended 1998 to include electronic and information technology, last amended 2017 - public)*; Air Carrier Access Act (1986, amended 2013 to include websites and automated ticket machines)*; Americans with Disabilities Act (ADA) (1990, last amended 2016)*; Section 255 of the Telecommunications Act (1996, last amended 2017)*; ADA Amendments Act (2008); ADA Standards for Accessible Design (2010 - public)	x, o

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Other		
Australia	Disability Discrimination Act (DDA) (1992, last amended 2016)*; WWW Access: DDA Advisory Notes (2014)*; Digital Service Standard (2015 - public)*	x
Brazil	Government Electronic Accessibility Model (2005 - public)	x
China	Law on the Protection of Persons with Disabilities (1990, last amended 2008)*	o
Hong Kong	Guidelines on Dissemination of Information (1999 - public)*	x
India	Guidelines for Indian Government Websites (2009 - public)*	x
Israel	Equal Rights of People with Disabilities Act (1998, last amended 2012)*	x
Japan	Basic Act on the Formation of an Advanced Information and Telecommunications Network (2000)*	o
New Zealand	Human Rights Act (1993); Online Practice Guidelines (2013 - public); New Zealand Government WA Standard 1.1 (2019 - public)*	x
Republic of Korea	Persons with Disabilities Welfare Act (2008)*	o

Appendix B

Informants and interviews

Table 14: Product team member informants and interviews.
C = consultant, E = employee.

Team	**Role, C/E**	**IT background**	**Accessibility background**	**Interview**
A	Designer, C	11 years in the IT; 4 years of UI and UX designing	Understanding of users' needs and the importance of accessibility; knowledge due to personal interest	7/5/2019, 30 min, Finnish, face-to-face
	Developer, C	10 years of developing	High-level knowledge from studies since 2007; technical experience from a previous project for a public sector body in 2015-17	9/5/2019, 35 min, Finnish, face-to-face
	Designer, C	10 years of visual designing; 4 years of UI and UX designing	Knowledge due to personal interest from the last few years	13/5/2019, 32 min, Finnish, face-to-face
	Product Owner, E	19 years in the IT; 5 years as an online business PO	High-level understanding	17/5/2019, 51 min, Finnish, face-to-face
	Tester, C	12 years of UI and quality testing	High-level understanding	17/5/2019, 38 min, English, face-to-face
	Developer, C	20 years of developing	None	21/5/2019, 38 min, Finnish, face-to-face

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B	Tester, C	Almost 20 years of testing	High-level understanding from working together with the designer at the current project; personal interest	6/6/2019, 44 min, Finnish, face-to-face
	Developer, E	9 years of developing	Knowledge from an accessibility workshop held in 2018	6/6/2019, 32 min, English, face-to-face
	Developer, C	8 years of developing	Technical experience from a previous project for a public sector body	7/6/2019, 30 min, Finnish, face-to-face
	Designer, C	Almost 20 years of frontend developing and designing	High-level understanding from a previous project since 2014; experience from the current project	11/6/2019, 46 min, Finnish, face-to-face
	Developer, C	22 years of developing	Good overall understanding and high-level technical knowledge from a previous project	12/6/2019, 49 min, Finnish, face-to-face
	Product Owner, E	Almost 20 years in the telecommunications business; 5 years as an online business PO	High-level understanding forming since 2016	12/6/2019, 44 min, Finnish, face-to-face
C	Product Owner, E	25 years in mobile video business	High-level understanding of users' needs and the importance of accessibility	14/6/2019, 46 min, Finnish, online call
	Developer, C	10 years of developing	Technical experience from a previous project for a public sector body in 2016-17	18/6/2019, 33 min, Finnish, face-to-face
	Designer, E	5 years of developing and designing	High-level knowledge from studies since 2013; high-level understanding due to personal interest	19/6/2019, 57 min, Finnish, face-to-face
	Designer, E	11 years of designing;	Experience on driving accessibility implementation at a previous employer since 2017; personal interest	25/6/2019, 52 min, English, face-to-face

Table 15: Organisational context informants and interviews.

Role / Team	**Background**	**Accessibility background**	**Interview**
Company Responsibility Director	12 years of different leadership and strategy positions with a sustainable development angle; 3 years as a responsibility expert; now the responsibility director for the past 3 years	High-level knowledge and experience from previous responsibility positions	16/5/2019, 52 min, Finnish, face-to-face
Senior Service Designer	16 years of front-end developing and designing at the company	High-level knowledge, understanding and experience from the past few years	17/5/2019, 37 min, Finnish, face-to-face
Senior Test Expert	22 years of software engineering and testing	High-level knowledge since 2011; deeper knowledge and understanding due to SEO since 2018	23/5/2019, 38 min, Finnish, face-to-face
Design System Team (lead designer, two developers)	Lead designer with over 15 years of design experience; developers with around 10 or more years of experience	High-level understanding, some concrete experience	1/7/2019, 34 min, Finnish, face-to-face

Appendix C

Case interview agenda

Introduction of the study and the interview process

Seventeen of the interviews were held in Finnish and three in English. The same agenda was used for both interview languages. In the beginning of each interview, I informed the participants about the objectives of the study and the content of the interview. They were also asked for permission to record the interview and use the interview as a part of the study. In order for the participants to feel comfortable sharing their thoughts and experiences, they were told that the results would only be shared anonymously as possible[1] both inside and outside the company. It was also emphasised that there were no right or wrong answers, only personal experiences and interpretations.

Interviewee background

- What is your **current role** and responsibility in your team/company?
  How long have you worked at the company?
  Have you had different roles at the company?
- What have you done **before** working at this company?

[1]Due to the small number of interviewees in each role, complete anonymisation was not possible. Thus, the interview results are mostly utilised in small masses, except in the case of the organisational interviewees who were the only representatives of their roles.

Accessibility knowledge and experience

- What is your **background** related to **web accessibility**?
- If the interviewee has accessibility **experience**:
  How was accessibility part of your daily/sprintly work?
  How did you experience it?
  Was there anything that stayed with you after your accessibility project(s)?

Work in an agile software development team (team context)

- Do you use an **agile framework** to manage your project and team?
  Can you describe your agile ways of working?
  What sort of events structure your work?
- How do you **plan** and share tasks with your designer/developer/tester colleagues?

Work in a large organisation (organisational context)

- Does your team work closely with **other teams** in the company?
  How is the collaboration visible?
  Do you share knowledge with your colleagues from other teams?
- Do you use the **design system and pattern library** of your company?
  To what extent do you use it?
  How do you use it?
  Does the DS/PL support you in your work?
  Does it pose as a challenge?
  Has utilising DS/PL impacted your/your team's ways of working?

State of accessibility and practical accessibility

- Have you been **testing** accessibility of your product/service with testing tools, accessibility professionals or experts by experience?
  Do you evaluate the state of accessibility in any other way?
- How do you proceed with accessibility findings?
  How do you think users with disabilities are **currently** taken into account in your product/service?
  How does accessibility implementation fit into your **project practices**?

End of the interview

- Is there anything you would like to point out or discuss further?
- Would you like to say something regarding the interview in general?

Appendix D

Accessibility evaluations

Accessibility evaluations on three digital products and services of the case company were conducted as a part of this study. The evaluation findings indicate that the state of accessibility should be improved in the context of the case company. The key challenges found during the evaluations are presented below.

Product	**Key identified challenges**
Customer self-service platform (Team A)	**Technical issues:** Undefined language; Empty links; No "skip content" links; Several equal navigations exist; H1 element is missing completely, H2 elements do not exist, H5 and H6 elements are used excessively; Mobile navigation has not been hidden from the hierarchy in desktop view; Only few navigation elements can be accessed (keyboard or screen reader); Navigation order on the website is illogical; Javascript-generated links are not recognised as links (screen reader); Some tabs or buttons cannot be accessed (keyboard or screen reader); Informative popups are entered on screen reader even when they have not been activated
	Design issues: General element focus styles do not exist or they are inconsistent (hover styles not sufficient)

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	Content issues: Missing alternative texts for images
E-commerce website (Team B)	**Technical issues:** Empty links; No "skip content" links; Parts of the navigation are passed when navigating, search field and shopping cart cannot be accessed (keyboard or screen reader); Several H1 elements on each page, H2 elements are missing, large number of H4s, H5s and H6s; Missing page landmarks and roles; Forms and radio buttons are not keyboard or screen reader accessible
	Design issues: Colour contrasts, especially in buttons; General element focus styles do not exist or they are inconsistent (hover styles are not sufficient)
	Content issues: Missing alternative texts for images
Audio-visual media service (Team C)	**Technical issues:** Undefined language; Search field is entered using when it has not been activated (keyboard or screen reader); Search field can be accessed but not exited (keyboard or screen reader); H1 and header image alternative texts are the same; Long horizontal lists of items (scrollable) cannot be skipped (keyboard or screen reader); Video on the top of a page cannot be accessed at all (keyboard or screen reader), once a video is on full-screen mode, it cannot be paused (keyboard or screen reader)
	Design issues: Colour contrasts, especially in buttons
	Content issues: Missing alternative texts for images; General element focus styles do not exist or they are inconsistent (hover styles are not sufficient)