

# **Characteristics of an accessible web product and how to implement them**

**Recommendations for Brella Oy**

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## Abstract

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Abstract <p>One billion people, more than 15% of the world, are disabled, excluding people with disabilities due to ageing. Blinded by short-term gains, businesses tend to neglect the accessibility of their web products, although the number of lawsuits against inaccessible websites is rising. With stricter laws, companies are forced to consider dissimilar user needs, which should not be the case. Accessibility has to be consulted because of its benefits to all parties. Starting small, the author decided to examine the accessibility of the product of her employer – a SaaS company. The researcher evaluated the current accessibility level of the product, surveyed the team to know its views and wishes, and issued recommendations that could help the company build accessible software.</p> <p>The thesis project followed the framework of design science research (DSR) and delivered the list of suggestions as an artefact. From the DSR perspective, the author identified the problem, justified the solution, and developed it. To find supporting ideas for the suggestions, the researcher conducted a literature review. Thanks to the mixed method research type, quantitative and qualitative data were collected. The former helped to assess the scope of the problem, while the latter – understand the reasons behind it and the professional views and wishes of the company. Finally, the three information sources were compiled into the project artefact – accessibility-improving recommendations.</p> <p>Accessible web products are Perceivable, Operable, Understandable, and Robust. Accessibility does not oust customisation opportunities or elaborate UX design. On the contrary, it supports the former and is intertwined with the latter. The process takes time and costs work hours, but product accessibility can be improved by as small as one-person teams by following international guidelines and auditing results. The most crucial element is an empathetic and benevolent attitude. The approach transformation is required as accessible software development is a long-term investment into user and designer/developer satisfaction. These and other findings are also reflected in the recommendations to the company.</p>		
Keywords accessibility, web, design, disability, WCAG, guideline		

## Contents

1	Introduction.....	1
1.1	Research background.....	1
1.2	Research objectives and delimitations .....	2
1.3	Research questions .....	3
1.4	Research framework.....	3
1.4.1	Structure of design science research.....	4
1.4.2	Applied design science .....	6
1.5	Research strategy: type of research and data collection and analysis methods .	8
1.5.1	Research approach.....	9
1.6	Case company .....	9
1.7	Thesis structure .....	10
2	Accessibility and the web .....	12
2.1	Accessibility as a tool of empowerment.....	12
2.2	Accessibility in practice .....	13
2.2.1	Categorisation of disabilities .....	13
2.2.2	Difference between accessible and assistive technology .....	13
2.2.3	Accessibility and general quality of life .....	15
2.3	Barriers to accessibility .....	15
2.4	Inclusive, usable, accessible .....	16
2.5	Accessibility and the web: application and summary.....	18
2.5.1	Application of facts and theory to the design science project .....	18
2.5.2	Chapter summary .....	19
3	How accessibility is reached .....	20
3.1	Accessibility standards .....	20
3.1.1	User Agent Accessibility Guidelines (UAAG).....	20
3.1.2	Authoring Tool Accessibility Guidelines (ATAG).....	20
3.1.3	Web Content Accessibility Guidelines (WCAG).....	21
3.1.4	International standards as the basis for national laws .....	22
3.2	Detailed view on WCAG 2.1 .....	23
3.2.1	How to make a Perceivable website .....	23
3.2.1.1	Level A .....	23
3.2.1.2	Level AA.....	24
3.2.2	How to make an Operable website .....	25
3.2.2.1	Level A .....	25
3.2.2.2	Level AA.....	26
3.2.3	How to make an Understandable website .....	26
3.2.3.1	Level A .....	26

3.2.3.2	Level AA.....	26
3.2.4	How to make a Robust website .....	27
3.2.4.1	Level A .....	27
3.2.4.2	Level AA.....	27
3.3	Theory of accessibility evaluation .....	28
3.3.1	Accessibility assessment tools.....	28
3.4	Accessibility and good design.....	31
3.4.1	Definition of good design .....	31
3.4.2	Interconnection between good design and accessibility .....	32
3.4.3	Combining good design and accessibility .....	32
3.5	Accessibility and customisation .....	33
3.6	How accessibility is reached: application and summary.....	35
3.6.1	Application of facts and theory to the design science project .....	35
3.6.2	Chapter summary .....	36
4	Automated accessibility assessment of the Brella platform .....	37
4.1	Platform introduction .....	37
4.2	Assessment results.....	39
4.2.1	Brella from the perspective of Wave.....	39
4.2.2	Brella from the perspective of ARC Toolkit.....	42
4.2.3	Assessment results: summary .....	45
5	Learning about the views of the Brella team .....	47
5.1	Questionnaire design.....	47
5.1.1	Research sample .....	47
5.1.2	Ideation of questions.....	47
5.2	Questionnaire findings .....	49
5.2.1	Data acquisition process.....	49
5.2.2	Analysis of the collected data .....	49
5.2.3	Summary of the findings .....	53
6	Accessibility-improving recommendations .....	55
7	Conclusion.....	57
7.1	Answers to the research questions.....	57
7.2	Validity and reliability .....	59
7.3	Suggestions for further research .....	59
	References .....	61

## Appendices

### Appendix 1. Questionnaire responses

## List of figures and images

Figure 1. Design science framework (Hevner et al. 2004, 80) .....	5
Figure 2. The process model of design science methodology (Peppers, Tuunanen, Rothenberger, & Chatterjee 2008, according to Brocke et al. 2020, 6).....	6
Figure 3. Design science process model (adapted from Peppers et al. 2008).....	7
Figure 4. Design science grid, the first version (adapted from Brocke & Maedche 2019, 7) .....	7
Figure 5. Thesis structure.....	11
Figure 6. Design science grid, the second version.....	18
Figure 7. The POUR flow (Duggin 2016).....	21
Figure 8. Design science grid, the third version .....	35
Figure 9. The word cloud of accessibility definitions given by the questionnaire respondents.....	50
Figure 10. Ratings of the current accessibility performance of Brella .....	50
Figure 11. Coding stripes used to scan answers for accessibility-supporting activities ....	51
Figure 12. Accessibility blockers mentioned by respondents .....	52
Image 1. Recent feature release - redesigned people view (Brella 2021b).....	10
Image 2. Refreshable Braille display (Appspringtech).....	14
Image 3. HTML type="text" attribute in use (WebAIM 2021b).....	23
Image 4. Example of information conveyed with colour and font .....	24
Image 5. Example of a user being in control of automatic updates.....	25
Image 6. The user interface of AChecker.....	29
Image 7. The user interface of Wave .....	30
Image 8. The user interface of ARC Toolkit .....	31
Image 9. Customisable colours on Brella .....	34
Image 10. Example of an event home page on Brella.....	37
Image 11. Matchmaking page on Brella .....	38
Image 12. Example of an event schedule on Brella .....	39
Image 13. User interface element on the home page .....	40
Image 14. Attendee profile on the matchmaking page.....	40
Image 15. A part of the event agenda .....	41
Image 16. Page numbering in the matchmaking section.....	42
Image 17. Example of assessment output on ARC Toolkit .....	43
Image 18. Keyboard user journey on the home page .....	44
Image 19. Application of the aria-hidden attributes to icons.....	45

## **List of abbreviations, concepts, and terms**

Agile team – a cross-functional group of 5-12 individuals who design, produce, and test working increments of a software product in a short amount of time – all by following the agile methodology

ARIA – Accessible Rich Internet Application, a guideline that specifies roles and attributes for better readability of dynamic websites by assistive technologies

B2B – a business-to-business model of enterprise operations

B2C – a business-to-consumer model of enterprise operations

DOM – Document Object Model, a data representation of content and structure of webpages

Down-event – an event caused by the clicked down left mouse button

EU – the European Union

OKRs – Objectives and Key Results, a goal-setting technique

Parsing – a procedure of transforming formatted text into a data structure

Refactoring – a process of improving and restructuring existing code without adding new functionality

Slack – one of the most popular workplace messaging tools

SaaS – Software as a Service, a software distribution model

UX & UI design – user experience and user interface design

## 1 Introduction

### 1.1 Research background

Inclusion is a global trend. At workplaces, shops, and on social media – representatives of online and offline worlds make statements about embraced diversity and aim for spreading awareness. As a result, more people feel involved and valued regardless of varying backgrounds and physical traits (W3C Web Accessibility Initiative 2010).

The trend is also visible in the IT sector. On the one hand, industry giants openly strive for fighting gender and racial inequality among staff. On the other hand, more businesses are becoming concerned about web accessibility due to both good intentions and a growing number of lawsuits against inaccessible websites (Hak 2020).

For the reasons explained above, accessibility is a popular word today. Nevertheless, UX & UI design courses at LAB University of Applied Sciences (UAS) familiarise students only with its basics. Ultimately, due to the current lack of personal awareness, interest in, and the increasing importance of accessibility, the author examines it in the thesis.

The researcher is employed at a SaaS company. Its product is an event platform that exists as web and mobile applications. Although Brella has expressed no interest in research activity, the design team (which is a part of the product team) is sure the company is at the beginning of its journey towards accessibility.

More than 15% of the world population is defined as disabled (World Bank Group 2021). However, this does not mean these individuals cannot afford products or services. On the contrary, the global disability market is estimated at \$7 trillion, excluding ageing people with unofficial disabilities and solid spending power (W3C Web Accessibility Initiative 2018a). Nevertheless, the statistics are still not convincing for many businesses since very few adapt their websites to meet accessibility criteria (AccessiBe 2019). As a result, up to a billion potential customers are lost.

In the setting of a pandemic, one billion people might have been disconnected from the world for 2 years. Work, shopping, and events – everything has rapidly transferred to online. If employers or teachers of disabled people had adopted inaccessible services, the routines of the latter immediately became extremely complicated.

The UN states that access to information on the web is a key human right. The EU authorities support it via recently adopted legislation (Hak 2020). For instance, the 2019 European Accessibility Act requires e-commerce websites and applications to become accessibility-friendly by 2025 (Deque Systems 2020).

For these reasons, the author brings attention to digital accessibility within the student and teacher communities at LAB UAS and beyond. Generally, accessibility practices enhance usability, readability, and design. They serve the varying needs of the permanently and temporarily disabled, ageing population and everyone who uses a device in extraordinary circumstances – on the very loud subway or sunny street. It is an era of user experience, and users are different.

The thesis work aims to strengthen the accessibility and inclusion of the web products of Brella. The research validates previously implemented accessibility features and produces improvement recommendations. The company, in turn, can potentially increase the market penetration rate by acquiring thousands of people left out by event platforms and organisers. In the event technology industry, Brella may pioneer a new inclusive approach to making experience, knowledge, and networking accessible to everyone.

## 1.2 Research objectives and delimitations

There are several objectives outlined for the thesis:

- Clearly define accessibility and its forms using literature sources. Investigate its connection to other terms such as inclusive, usable, or universal.
- Do discovery on approaches, methods, and techniques of accessibility implementation.
- With the accumulated theoretical knowledge, assess implemented accessibility features and overall performance of Brella.
- Understand the product team of Brella: its perception of accessibility and desirable direction of development.
- Based on the theory and wishes of the product team, provide recommendations of the most suitable solutions for making a website/web application in question more accessible.

The following factors restrict this thesis project:

1. Time. The length of the research depends on fixed graduation dates. Therefore, the project span takes only several months.
2. Focus. Brella has a website, web application, and native mobile apps. Nevertheless, the study does not consistently cover all of them. Due to the vast availability of topical literature and standards, the web presence of the company is given priority.



3. Target population. Data collection is directed at the product team of Brella, as their responses are crucial in shaping recommendations for the company.
4. Delivery scope. Recommendations are presented in the text form and not as ready-made demonstration material. Although feature implementation could be done with, for instance, SwiftUI, that could cause prolongation and focus shift.

### 1.3 Research questions

In a discussion, the designers of Brella have shared the subsequent thought: whenever it comes to costly and peculiar products such as event platforms, customers demand customisation. However, how can accessibility and proper design be ensured for attendees? Conversations with the team have provided a foundation for research questions.

The main research question follows:

**What are the characteristics of an accessible web product and how to implement them?**

The sub-questions are meant to enrich the report with related topics:

- How to make a website/web application inclusive by means other than accessibility?
- Are accessibility and proper professional, academically acknowledged design complimentary or contradicting concepts? If they are matching, how to combine both?
- With an accessible and well-designed app, how to give the maximum of customisation opportunities to customers/users?

### 1.4 Research framework

Research methodologies help researchers consistently plan studies and answer research questions (Kothari 2004, 8). The methodology that this thesis follows is design science. Accompanying behavioural science, design science is one of the two paradigms prevailing in Information Systems (IS) research (Hevner, March, Park & Ram 2004, 75).

Design science seeks to create new objects and bring value to people and organisations. In the information technology (IT) sector, the objects are referred to as IT artefacts that can take any form from texts in natural language to working software. (Hevner et al. 2004, 77.) The starting point of design science research is problem investigation. Specifically due to the orientation on performance enhancement, design science holds the unofficial name of "improvement research". (Vaishnavi & Kuechler 2004, according to Järvinen 2005, 8.) The

goal of design science is value formation through utility, which explains the popularity of the paradigm in the technology field in general (Hevner et al. 2004, 80). The dominance of design science in particularly IS research is partly connected to the following reasons:

1. The aim of digital products (except malware) is to increase organisational efficiency and improve human lives. Thus, IT artefact creation has a design science intent – performance improvement and problem-solving (March & Smith 1995, 256). Therefore, design science ideologically complements the IT industry.
2. Corporate IT systems function in vivid ecosystems made of companies, their employees, infrastructures, and procedures. When targeting a certain issue, design science considers all the elements and the environment in general to maximise learning about the problem space. (Hevner et al. 2004, 78.)
3. Similarly to many other concepts used in IT (for example, waterfall software model and quality assurance practices), design science originates from engineering, which may explain the simplified applicability of the research paradigm (Hevner et al. 2004, 76).
4. Design science research addresses wicked problems, which are prevalent in software engineering (Hevner et al. 2004, 81). Thus, by following design science, software professionals can solve non-trivial issues in unstable contexts.

#### 1.4.1 Structure of design science research

Despite the same wording, design science and ordinary design operations differ. The routine design applies an existing knowledge base, while design science innovates on and extends it (Hevner et al. 2004, 81). The innovative results are achieved by following the design science framework from Figure 1.

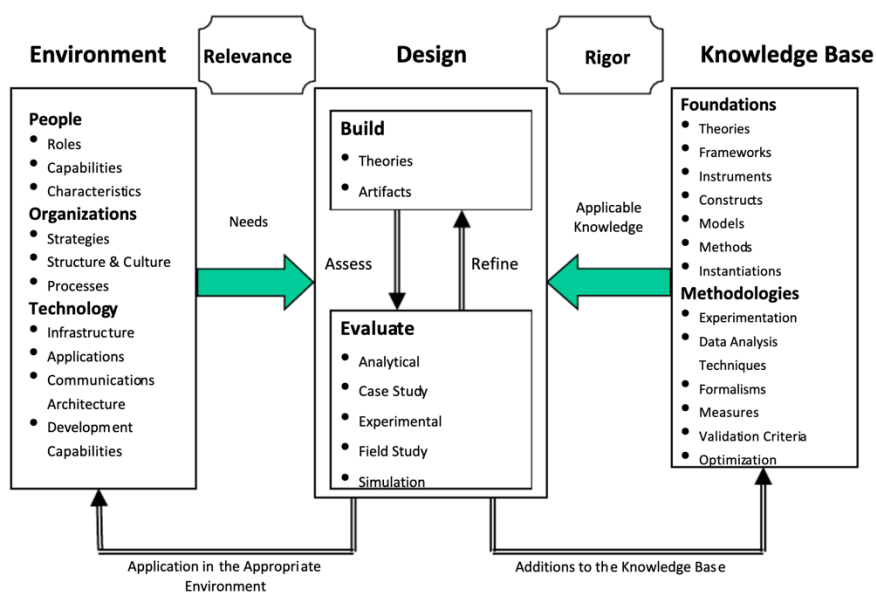


Figure 1. Design science framework (Hevner et al. 2004, 80)

In Figure 1, the environment comprised of people, organisations, and technology, on the one hand, shapes needs that require an unconventional response. These needs consequently become a research problem for design science research, which guarantees the relevance of the scientific activity. Knowledge base, on the other hand, plays the role of raw material for fruitful design science and generates rigour. Foundational theories and methodologies are applied throughout the project to build and evaluate resultant artefacts. (Brocke, Hevner & Maedche 2020, 3.)

Centred in Figure 1, the creation and evaluation of artefacts are an iterative process. In addition to environment and theory analysis, the active phase of design science may involve traditional research methods of interviews and surveys. The final product of design science research serves as an addition to the knowledge base and an instrument usable in the designated environment. (Brocke et al. 2020, 5.)

In design science, the IT artefacts are categorised into instantiations (working and prototyped systems), methods (best practices and guiding algorithms), models (illustrations and abstractions), and constructs (symbols and terminology) (Hevner et al. 2004, 77). Generation of accessibility-related recommendations, which is a key objective of the thesis, correlates with guiding Brella to accessibility in its web products. Furthermore, as mentioned among research limitations, prototype development based on the recommendations is beyond the project scope. Hence, methods are the **target artefact** of this thesis project.

## 1.4.2 Applied design science

Several characteristics subsume the thesis under applied research as opposed to basic. Firstly, the project is working-life oriented, as it seeks to solve a problem of a company by developing its product. Secondly, the thesis context is twofold and set by both the business and university. The context duality has influenced the topic formation and given a soft time frame. Thirdly, the report aims for using professional language and concepts to align with the product team of Brella. (Fifield & Laisi-Wessman.)

To help researchers follow design science, Peffers, Tuunanen, Rothenberger, and Chatterjee (2008, according to Brocke et al. 2020, 6) have developed a process model depicted in Figure 2. It comprises six steps: problem identification, objective definition, design and development, demonstration, evaluation, and communication of a solution. As the artefact creation is the main objective of the thesis, design and development is the last step that the report covers. Demonstration, evaluation, and communication are supposed to be organised by the author together with Brella as soon as the report is finalised. Therefore, these steps are not documented.

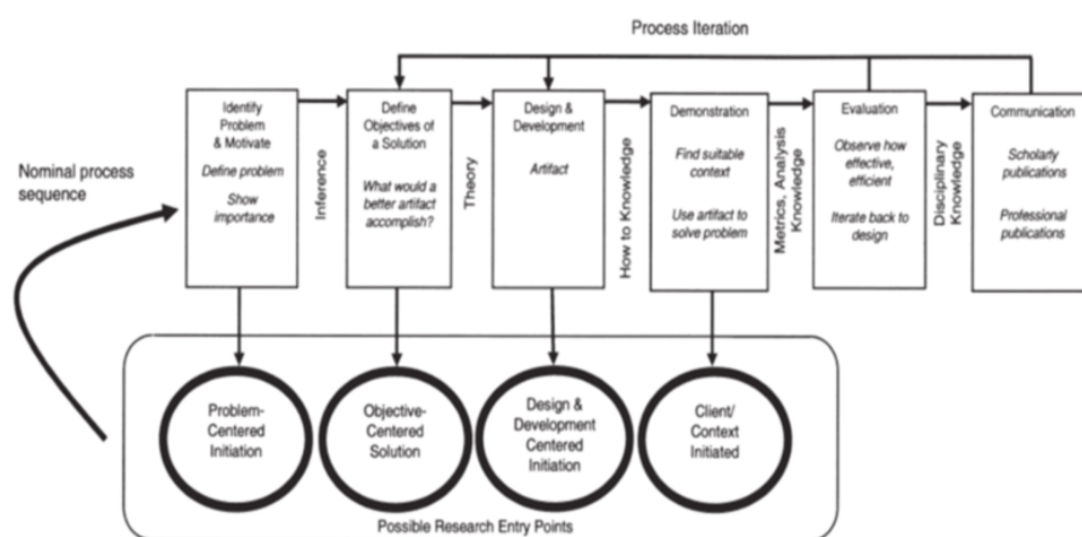


Figure 2. The process model of design science methodology (Peffers, Tuunanen, Rothenberger, & Chatterjee 2008, according to Brocke et al. 2020, 6)

As the first step, a researcher identifies and motivates a problem. In other words, s/he defines the problem area and explains the importance of a solution. The second step is the objective definition, where a researcher concludes the artefact goals based on the identified problem. For the third step, an artefact is designed and developed. (Brocke et al. 2020, 6)

To be aligned with the process model, the author has created its simplified version to resort to at different stages of the thesis (Figure 3).

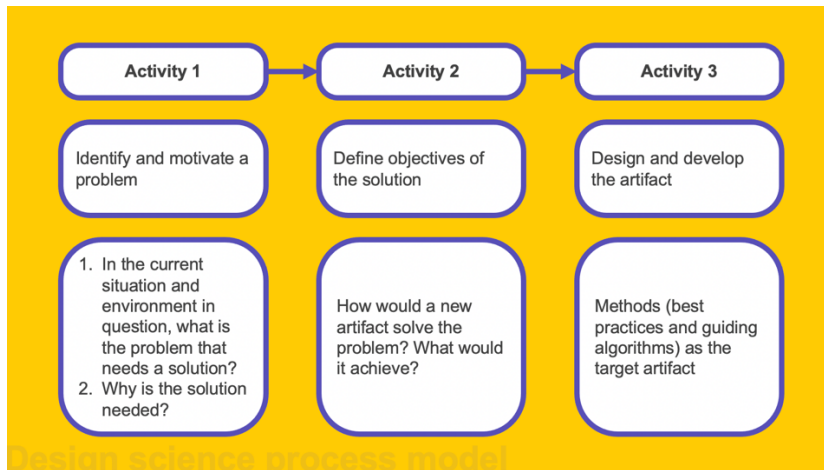


Figure 3. Design science process model (adapted from Peffers et al. 2008)

Additionally, the researcher has adapted the Design Science Research Grid of professors Brocke and Maedche to the needs of the report (Figure 4). The grid highlights essential elements of design science and, hence, supports the paradigm implementation. The researcher uses the framework to record design science project components as they emerge throughout the thesis.

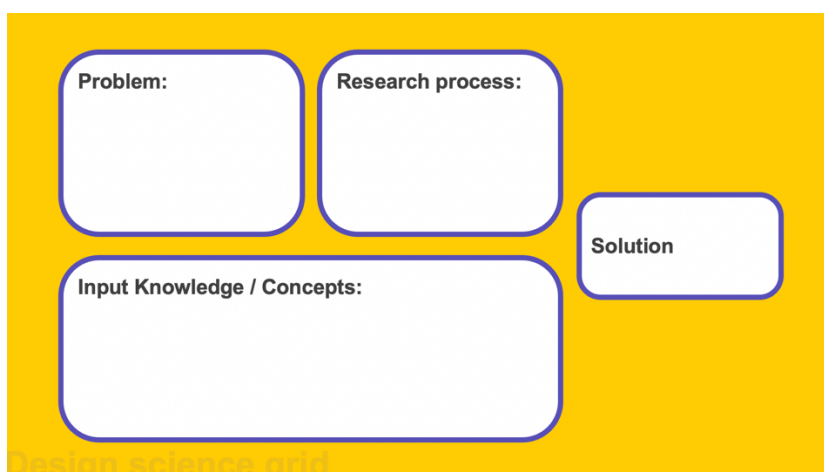


Figure 4. Design science grid, the first version (adapted from Brocke & Maedche 2019, 7)

## 1.5 Research strategy: type of research and data collection and analysis methods

The major research types are differentiated as qualitative, quantitative, and mixed method. Qualitative research analyses human activity through observation and words to maximise understanding of a certain phenomenon (Vuorela 2021). Results in quantitative research rely on statistical procedures with numerical data (Fifield & Laisi-Wessman). The mixed method research, as the name suggests, combines the characteristics of both and strives for reflecting a bigger picture.

Most research questions in section three begin with the word “how”. This showcases the aim of the author to understand the accessibility phenomenon and describe its essence. Additionally, the objective to explore how designers and developers at Brella regard accessibility similarly justifies the choice of qualitative data collection methods. (Vuorela 2021.)

As for other objectives of the thesis, it targets assessing the current performance of Brella in terms of accessibility. During the project, the assessment was automated and executed via dedicated software, which measured accessibility compliance and returned a certain adherence score. Furthermore, the author could rerun the evaluation without limitations in attempts. (Regoniel 2015.) These indicate a quantitative research perspective. Therefore, the overall type of research is **mixed method**.

Mixed method research unlocked multiple data collection methods. The author used questionnaires with mainly open questions to collect primary data and learn about the views of the Brella team. Due to the small sample size, response analysis was manageable. The questionnaire was chosen over interviews due to the varying remote locations of many target group representatives. What concerns primary quantitative data, it was received from accessibility measuring software. Secondary data accumulated via literature review assisted in answering sub-questions of the research.

When it came to data analysis methods, **thematic analysis** was given priority for qualitative data. The process considered subjective views and experiences, categorised data into batches, and gave them meaning (Crosley 2021). Qualitative data visualisation techniques such as word clouds, charts, and coding stripes fostered the analysis. All of these helped in interpreting the thoughts and ideas of the product team and assisted in providing accessibility-improving recommendations. As for quantitative data obtained through automated assessment, the findings were briefly analysed with descriptive statistics to provide readers with an understanding of the scale.

### 1.5.1 Research approach

What concerns the deductive and inductive research approaches, a compromise between the two was the solution – abductive. Being common in IT research, the abductive approach provides a researcher with significant flexibility in combining theory and practice. New findings are not treated as deviants but rather incorporated into existing theories (Awuzie & McDermott 2017, 357). In other words, if a definition of accessibility given by questionnaire respondents differed from the one obtained through the literature review, both would be considered in the empirical phase. According to Keski-Mattinen, the abductive approach is the most suitable for system analysis projects, which, similarly to the given thesis, aim for identifying better work practices. Comparably to design science, researchers are supposed to have auxiliary theories that guide them towards practical solutions.

### 1.6 Case company

Brella is the name of the market-leading platform for virtual, hybrid, and physical events and the Helsinki-based IT company mentioned in the beginning. The company mission states: people achieve everything with the help of others. Therefore, Brella stands for empowering individuals with access to relevant connections. The company mission is also reflected in the unique selling point of the product – an intent-based matchmaking algorithm powered by Artificial Intelligence. (Brella 2021a.) Keeping it as a core value, Brella, nevertheless, constantly seeks to innovate human interactions and has recently made one of the most visible releases of the year (Image 1).

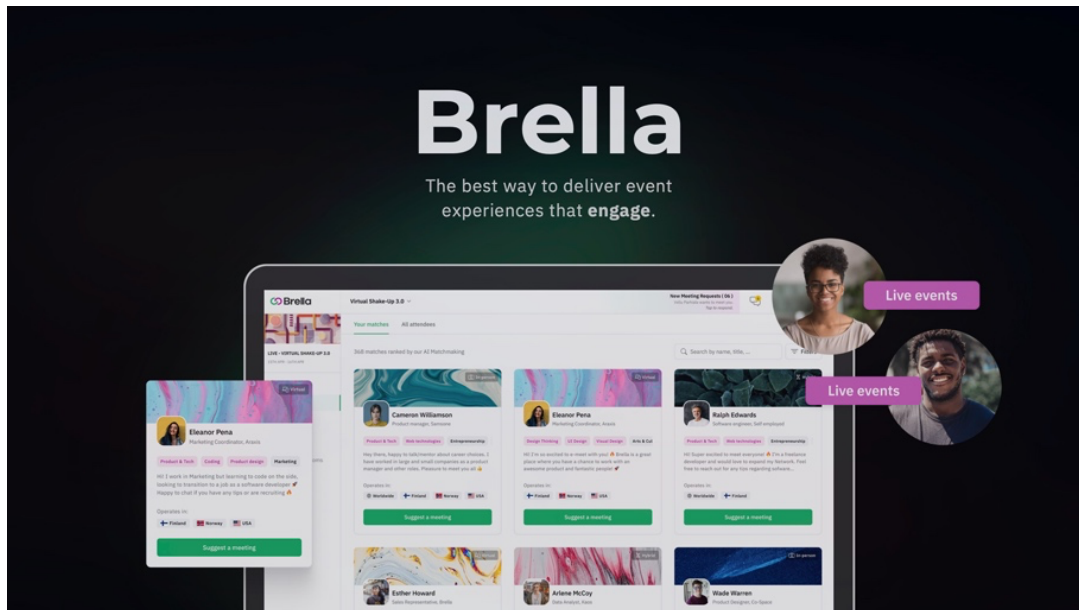


Image 1. Recent feature release - redesigned people view (Brella 2021b)

Networking opportunities unlocked by Brella allow event visitors, sponsors, and exhibitors to reach and exceed their business goals. For this reason, the platform is used at prominent events organised by Ericsson, IBM, and The Linux Foundation. (Brella 2021a.) The organisation comprises 61 employees and is continuously growing, as it successfully raised a \$10 million Series A funding round in June 2021 (Butcher 2021). Public communication channels highlight the current focus points of Brella: strengthening commercial presence in the USA, conquering competition with innovative feature releases, and providing best-in-industry customer experience.

## 1.7 Thesis structure

The report contains seven distinctive chapters, which provide structure and can be generalised as in Figure 5:



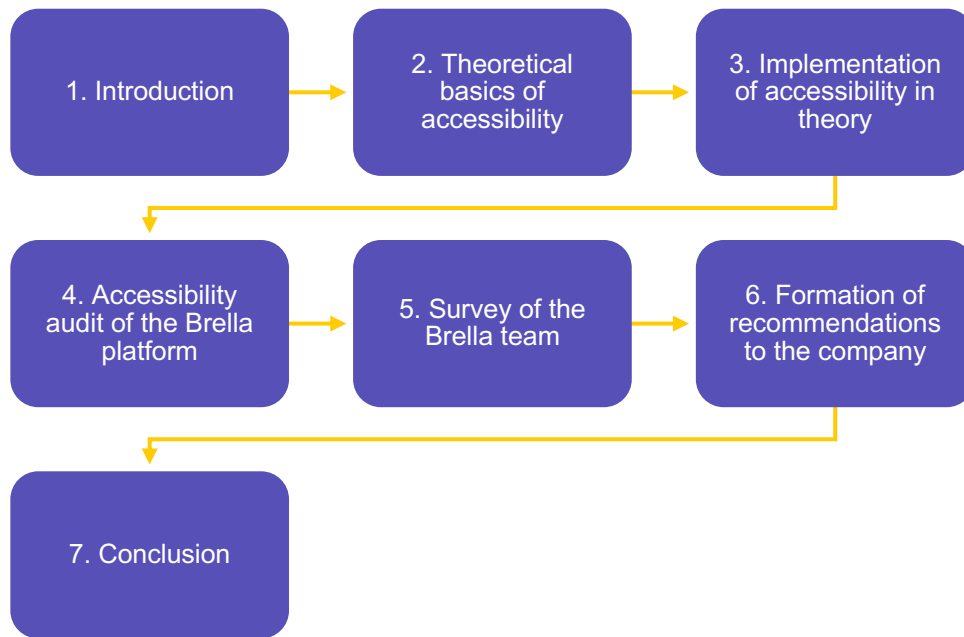


Figure 5. Thesis structure

## 2 Accessibility and the web

### 2.1 Accessibility as a tool of empowerment

Accessibility has never been related solely to the web or applications. It is a common characteristic to evaluate when, for example, assessing facilities and buildings. Nevertheless, these two perspectives on the concept are context-dependent and, hence, narrow. (Duggin 2016.)

In a wider interpretation, accessibility represents equal opportunities for everyone to meet their needs with equivalent time and effort regardless of physical and mental state. Disabilities must not be barriers to information, interactions, or joy. Accessibility also emphasises ease of use of products and services. Thus, design and implementation should not frustrate people but empower them with confidence and independence. (South Carolina Technical College System OCR Compliance Review 11-11-6002/2013; Duggin 2016.)

Accessible technology is successfully used by people with disabilities at any time and without additional modifications. However, the reality is that the extraction of certain information often requires the use of intermediary devices. Depending on the nature of the disability, the tools range from screen readers to alternative keyboards. Unfortunately, due to scarce supply, these special devices tend to be expensive. Furthermore, separate massive equipment serves as a label and excludes its holders from interpersonal interaction. Therefore, accessible content is the most scalable and delicate approach to increasing inclusion and information sharing. (Lazar, Goldstein & Taylor 2015, 17.)

In turn, **web accessibility** ensures everyone is included when it concerns understanding, navigating, and contributing to the content on websites and applications. Tim Berners-Lee, the inventor of the World Wide Web, is convinced that his creation will unlock its full potential when it reaches everyone regardless of ability, location, or language. (W3C Web Accessibility Initiative 2005a.)

Overall, accessibility exists in different forms but always aims for absolute inclusion and empowerment. Accessibility in technology and specifically the web makes interaction with websites effective for users with information processing difficulties and without. For the past years, technological advances have integrated disabled people into the communication loop of the World Wide Web, but there is room for improvement in user experience. Separate devices make their owners feel different, web content – does not.

## 2.2 Accessibility in practice

Disability is frequently mentioned in discussions about accessibility. The UN Convention on the Rights of Persons with Disabilities (Article 1) (2006) interprets disability as a longstanding impairment of mental, physical, sensory, or intellectual nature, which can impede full participation in societal life along with others. According to the World Bank Group (2021), more than 15% of the world population, one billion people, is characterised as disabled. Thus, one in seven people has a limited entry into society and its major activities. Disabilities that lead to that have various classifications as well as associated assistive technologies meant for eliminating barriers.

### 2.2.1 Categorisation of disabilities

The field of human-computer interactions divides permanent disabilities into the following groups:

- Perceptual disabilities (vision and hearing)
- Physical or motor disabilities (limitations of using hands and speech)
- Cognitive disabilities (for example, dyslexia).

These categories follow a computer-centric view. Understanding screen output is a challenge for those with difficulties in seeing or hearing (perceptual disabilities). Physical or motor disabilities hinder the process of inserting input into a machine. Cognitive impairments are separated as they are more complex for generalisation from the input-output point of view. To meet the needs of those with cognitive disabilities, the transformation of the information view may be enough. However, often adaptation options vary as much as the perceptual effects of cognitive disorders. (Lazar et al. 2015, 19.) Although disabilities significantly differ, the alignment to unified criteria such as computer input and output eases design considerations and helps teams better orient among diverse needs.

### 2.2.2 Difference between accessible and assistive technology

**Accessible technology** serves people with disabilities and without. Such technology considers multiple needs and environments from typical to unique ones. In the web context, it provides equal access to the content and functionality of websites. In case a piece of content is not adjusted to a required form (for instance, text to audio), the webpage must be developed with marked labels so that individual assistive devices can capture necessary information (Lazar et al. 2015, 28).

**Assistive technology** represents holistic hardware or software designed with one goal – to support disabled people in the completion of digital tasks (Inclusive Design Research Centre). Assistive devices are essential for people with impairments to use the inaccessible side of the web. There are several examples of assistive technologies:

- Screen readers provide the visually impaired with audio versions of content.
- Refreshable Braille display dynamically outputs a line of Braille characters. It connects to a device running a screen reader and uses the latter's wording to produce texts in Braille for the visually disabled. The basic mechanism of the device is depicted in Image 2.
- Speech recognition and input software assists people with physical disabilities in typing text or controlling a computer in ways other than with a mouse and keyboard.
- Speech to text converts audio and video content without subtitles into written text for people with hearing impairments.
- Text readers help people with cognitive disabilities such as dyslexia by reading words out loud and highlighting them simultaneously. (AccessibleTech.org.)



Image 2. Refreshable Braille display (Appspringtech)

As mentioned, accessible technology aims for minimizing the need for assistive devices and ensuring everyone can reach and contribute to the World Wide Web. An example of

accessible hardware technology is Apple MacBook and its in-built VoiceOver function, which replaces portable screen readers.

### 2.2.3 Accessibility and general quality of life

In addition to the above-mentioned, disabilities can be classified by reason:

- Environmental or situational (for instance, when using a mobile phone on a sunny street and not being able to read pale text)
- Incidental or temporary (for example, lack of sleep last night making words in work documents jump over the lines) (Interaction Design Foundation a).

This means that accessibility features are beneficial for people without official disabilities but in extraordinary circumstances. Furthermore, when reaching the 70<sup>th</sup> birthday, one has had to be living with an emerged disability for approximately eight years (Disabled World 2022). People also become temporarily disabled when seriously injured (W3C Web Accessibility Initiative 2005a). Thus, accessibility helps everyone as it addresses unique but existing user needs and contexts. After all, the world is using the fruit of accessibility daily when listening to e-books, watching videos with subtitles, or sending voice-typed messages. Although all definitions of accessibility refer to disabilities, the concept goes beyond them. The wide umbrella of disorders that accessibility serves creates out-of-ordinary use cases for people without physical or mental limitations.

## 2.3 Barriers to accessibility

Despite benefits for everyone, increased market opportunities, and demands of governmental organisations, accessibility is rare on the web (Adobe 2022). Few businesses adapt websites to meet accessibility criteria, and there are several reasons why (AccessiBe 2019). The World Health Organisation and World Bank (2011) outline the following barrier-causing factors:

1. Corporate standards and policies are either not enforced or do not consult accessibility.
2. Insufficient funding. Manual development of accessibility features takes the work hours of development teams. Quality work has to be compensated accordingly.
3. Due to deficient qualifications and training, the staff is unaware of accessibility requirements or unable to support them.
4. Disabled people are not involved in design and decision-making.

5. Data on disability and accessibility is not studied regularly and rigorously enough, which impedes development. The point relates to many data-driven companies that react fast to compelling research results such as the following: 40% of people change at least one accessibility setting of an iPhone in the Netherlands (Darovskaya 2022).
6. Personal stereotypes and prejudice affect the attitude to disabled people in work environments (Gilbert 2019, 3). For example, designers may assume any disability impacts cognitive capabilities (“A disabled event attendee would hardly understand anything!”) and omit the needs of the disabled. Another extreme is people becoming so emotionally concerned that they direct resources to worries and drama instead of acting (Darovskaya 2022).

These reasons partly explain why Brella has not gone far in the exploration of accessibility. Furthermore, its team consists of 25-35-year-old people who are young and healthy. Additionally, not many B2B customers have been emphasizing accessibility of the platform, whilst competitors prioritise other features as well.

Growth towards accessibility is a strategic choice that the management of Brella has to make. The choice follows readiness to invest in the short- and long-term. In case of a positive decision, accessibility improvement on the platform can be put among quarterly objectives and key results (OKRs). Thus, data on accessibility would receive constant visibility at the company.

To equip designers and developers with tools and confidence, training sessions could be organised. The involvement of disabled people would significantly boost the process, but diverse UX research and user personas are a solid start. Brella also has multiple marketing channels that could increase public awareness of accessibility and shed the light on the revolutionary competitive advantage of the company.

## 2.4 Inclusive, usable, accessible

People tend to think about themselves first and foremost (Gilbert 2019, 9). That relates to many fields of life including design. The process considers human beings alike as they behave and act similarly. People that differ the most receive the least or no attention. Inclusion strives for changing that approach.

**Inclusion** promotes diversity and ensures everyone is involved and considered regardless of age, gender, or ethnicity (Google Developers 2018). Inclusion shares values with the

design for all concept and universal design. Several aspects prove the inclusion of a website such as:

- Access from any geographic location (for instance, via a relevant country-specific domain)
- Content understandable by generations with different educational and cultural backgrounds (for example, with clear, unequivocally written texts)
- Functionality that suits different levels of computer literacy
- Adaptability to varying quality of Internet connection, software, or hardware (for instance, via media optimised to quick loading)
- Accessibility for disabled individuals. (W3C Web Accessibility Initiative 2010.)

Thus, inclusion is a broad concept that can be implemented in several ways including accessibility features. Ticked boxes in front of the inclusion technicalities and accessibility standards do correspond to formalities but, on their own, make a product hardly usable (Google Developers 2018). Therefore, teams reach their efficiency and quality goals whenever approaching accessibility, inclusion, and usability altogether.

**Usability** affirms satisfactory, effective, and efficient goal achievement with a product (ISO 9241-11). Usability is a result of diligent UX design with research, ideation, and prototyping activities. User research allows designers to know potential audiences as closely as possible. Nevertheless, disabled people are rarely the target of research interviews or observations (W3C Web Accessibility Initiative 2010).

Accessibility and usability are complementary concepts: the former benefits the latter, especially within extraordinary circumstances. To avoid product transformation into an interactive list of accessibility features, designers should involve disabled people in the process and work towards accessible user experience. People with disabilities are valuable consultants to be in touch with from the early project days, throughout development, and during testing and evaluation periods. (W3C Web Accessibility Initiative 2010.) The efforts required do not significantly differ from classic conversations with users. However, designers may wish to learn more about utilised assistive technologies and workarounds that help the disabled accomplish everyday goals (Google Developers 2018).

Accessible, inclusive, and usable are interrelated concepts to consult in web development. One way to make websites inclusive is to create them with accessibility in mind. However, the only way to bring value with a digital product is to make it usable. The three ideas coexist

when people with disabilities are involved in and navigate the design and development work.

## 2.5 Accessibility and the web: application and summary

### 2.5.1 Application of facts and theory to the design science project

As Figure 3 suggests, design science projects begin with problem identification. From the research perspective, the main shortcoming of Brella is the absence of a rigorous framework on accessibility adoption. Consequently, the company overlooks rare but direct customer questions on accessibility compliance and the \$7 trillion disability market.

To foster company evolution accessibility-wise, the solution has to become a solid starting point for inclusivity initiatives at Brella. Being dedicated solely to the company product, the recommendations are assumed to face low barriers to production. In addition to improved sales opportunities, accessibility-friendly Brella would become law-compliant in advance. As the EU accessibility legislation is expected to cover increasingly more aspects of society, the company would address the issue early and potentially become an example or consultant for other SaaS organisations. Other general benefits that web accessibility brings are listed in the following sub-chapter. Based on the analysis above and research type, the author has updated the design science grid with the problem and research process descriptions (Figure 6).

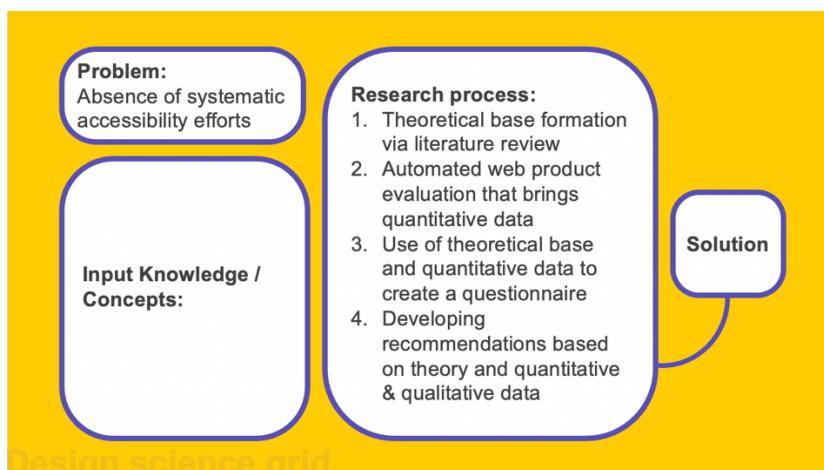


Figure 6. Design science grid, the second version



### 2.5.2 Chapter summary

Web accessibility encompasses two aspects. One of them relates to the user side and, specifically, how disabled people interact with the web. The aspect observes assistive technologies and workarounds users undertake to perceive content on inaccessible webpages.

The second facet of accessibility concerns the developer side and their actions towards the inclusive web. Product creators have to work on their biases and openly consider dissimilar user habits. Especially with commitment from the management and helpful insights that the aspect one holds, implementing accessibility does not vary from production for ordinary users yet

- serves people on different ability levels
- increases customer base and brings financial benefits
- represents a public-spirited activity that forms honest and positive PR.

The second chapter intends to answer general what-questions surrounding the accessibility topic. It has also attained one of the study objectives by defining accessibility and outlining the connection between it and other similar terms. Additionally, chapter 2 answers one of the research questions: how to make an application inclusive by means other than accessibility? The next chapter guides a reader into the means of reaching accessibility.

### 3 How accessibility is reached

Accessibility is easier to achieve when it is ingrained into product design and development from the beginning. Such an approach makes all potential users a priority, not an after-thought. In addition to starting early and solutions mentioned in chapter 2.3, accessibility experts Horton and Sloan (2014) suggest partnering with accessibility consultants. Professionals can give valuable advice at the beginning, examine progress along the way, and audit results. Nevertheless, following technical standards is still a dominant tool to implement accessibility.

#### 3.1 Accessibility standards

Accessibility guidelines incorporate provisions immediately applicable to product design and development, which eases the integration of inclusive practices. (Horton & Sloan 2014.) Some of the most widely accepted web accessibility standards originate at one organisation – the World Wide Web Consortium (W3C). Its time-tested expertise and efforts towards the Web Accessibility Initiative (WAI) have translated into universal recognition. The W3C WAI guidelines are referred to as UAAG, ATAG, and WCAG and are not legally binding on their own. (Lazar et al. 2015, 76.)

##### 3.1.1 User Agent Accessibility Guidelines (UAAG)

User Agent Accessibility Guidelines (UAAG) aim for accessibility improvement of user agents: web browsers, document readers, and other web content renderers. When developed with UAAG in mind, web browsers flawlessly interact with assistive technologies and enable convenient changes in text size and page scale. When User Agent Accessibility Guidelines are, on the contrary, neglected, even the most accessible websites become unreachable or incomprehensible for disabled people. Therefore, UAAG are an essential source to examine for user agent developers and decision-makers selecting user agents for their organisations. (W3C Web Accessibility Initiative 2005b.)

##### 3.1.2 Authoring Tool Accessibility Guidelines (ATAG)

Authoring Tool Accessibility Guidelines have two foci. The first one is increasing the number of accessible authoring tools so that disabled creators could effortlessly contribute to the web. The second focus point seeks to assist authors in the production of accessible web content. When ATAG are followed, the level of support that a tool provides corresponds to software producing accessible content by default. The target audience of ATAG involves authoring tool designers and developers – those working on content management systems

and HTML editors, for instance. However, with more software switching to the cloud-based model of distribution, it is important for teams to consultant ATAG and enable comparable access to education-, work-, and creativity-supporting tools for everyone. (Lazar et al. 2015, 81.)

### 3.1.3 Web Content Accessibility Guidelines (WCAG)

Issued by a reliable organisation, Web Content Accessibility Guidelines 2.1 (published in 2018) are internationally acknowledged standards. Internal and external stakeholders have made input into the creation of the guidelines, which has also resulted in the trust of the web development community. Despite the conceptual difference, website and web application accessibility shares the same goals. There are four foundational principles of web accessibility outlined in the document: Perceivable, Operable, Understandable, and Robust (POUR). (Lazar et al. 2015, 77.) As depicted in Figure 7, all the principles form a flow. If any of the four crucial elements is absent, disabled people are unable to accomplish tasks on the web.

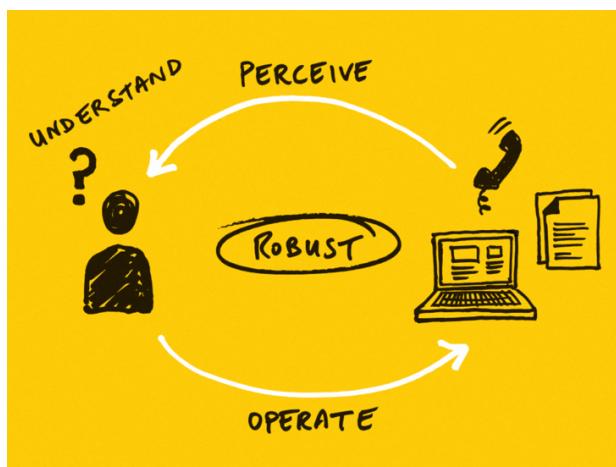


Figure 7. The POUR flow (Duggin 2016)

Perceivable content can be grasped with any sense available to a person. For instance, audio content on an accessible website is hearable but also visible with captions. Operability requires a user interface to work regardless of a navigation method – via keyboard or mouse. Understandable websites aim for decreasing cognitive load and making information and operations as unambiguous as possible. Robust content is available with technologies (including assistive devices and user agents) of varying novelty. (Lazar et al. 2015, 78; Accessibility Guidelines Working Group 2022.)

In the WCAG, each principle is a grouping basis for guidelines and success criteria. The latter are testable statements that, when applied, are either true or false. The success criteria indicate whether the accessibility guidelines and, ultimately, primary principles are followed. (Lazar et al. 2015, 79.)

Another essential attribute of the Web Content Accessibility Guidelines is conformance levels:

- **Level A** is a fundamental and minimal requirement that allows the disabled to use the web.
- **Level AA** marks general accessibility and the absence of serious barriers on the way of disabled people to web content. Most websites pursue specifically this level, which builds on the A grade.
- **Level AAA** comprises provisions of the previous levels, enhances accessibility (for instance, by highlighting speech pauses in video captions) and serves as a sign of excellence. However, compliance to the AAA level is sometimes unachievable. (WebAIM 2020.)

Noteworthy, WCAG, ATAG, and UAAG follow the structure and compliance levels alike. Unified guidelines and testable criteria help organisations instantly implement theories starting with smaller, A level, changes. Nevertheless, standards are not effective when used as a standalone tool. Indifference and consistent attention to people with disabilities have to become driving forces in design and development in the first place.

#### 3.1.4 International standards as the basis for national laws

As mentioned, WCAG and other complimentary guidelines are not legally enforceable on their own. Yet they have been successfully serving as templates for national and international legislation. Countries that have grounded their laws on WCAG 2.0 involve Australia, Canada, Denmark, and 21 more (W3C Web Accessibility Initiative 2018b).

In the US, Section 508 of the Rehabilitation Act is a federal law that instructs government-related entities to embrace accessibility in online activities, communication technology, and on websites. The law uses Web Content Accessibility Guidelines 2.0 when describing requirements for digital assets. If corporate websites and applications correspond to the AA level of the WCAG, the assets automatically comply with Section 508. (TPGi 2019.)

British Equality Act of 2010 and the European Web and Mobile Accessibility Directive follow the same logic. The laws address public service providers and require them to conform to

the AA accessibility level. Moreover, the Web and Mobile Accessibility Directive complements the European Accessibility Act, which targets the e-commerce sector as well. (Central Digital and Data Office 2018; Directorate-General for Communications Networks, Content and Technology 2022.)

The recognition of digital accessibility on the governmental level is a bright sign. As the EU legislation proves, the public sector is a starting focus for accessibility expansion. Therefore, zero legal pressure does not mean private businesses should ignore the WCAG. The recommendations are the opposite, and their advantages are listed in chapter 2.5.2.

## 3.2 Detailed view on WCAG 2.1

Brella has customers from all over the world. Hence, adherence to international standards such as WCAG 2.1 could potentially cover the most widespread country-specific accessibility requirements. This chapter examines WCAG 2.1 (W3C 2018) and recommendations that WebAIM initiative (2021a) from Utah State University provides. Since the AA accessibility level is the degree of compliance businesses aim for, A and AA guidelines are to be analysed.

### 3.2.1 How to make a Perceivable website

#### 3.2.1.1 Level A

Firstly, Perceivable websites offer text alternatives to non-textual content (**Guideline 1.1**). This way, people can transform text to speech or Braille via assistive devices. To enable that, developers add alternative text to images, explanatory value attributes to buttons, and text labels to inputs in forms (Image 3).

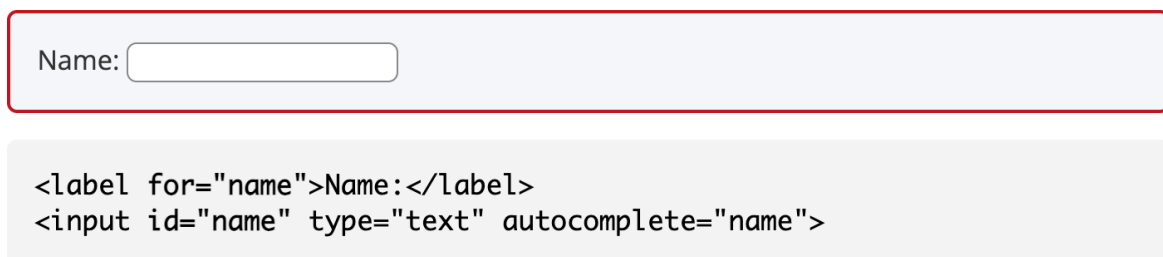


Image 3. HTML type="text" attribute in use (WebAIM 2021b)

Secondly, alternatives are given to prerecorded time-based media – informative audio and video elements that have a duration (**Guideline 1.2**). Audios are supposed to have a transcript of essential information mentioned. Videos should have either the same or an audio explanation of relevant content. In addition, video content needs synchronised captions. However, the requirement is disregarded when an audio or video is an alternative to a text.

Thirdly, on Perceivable webpages content keeps the same structure and information regardless of the way of representation (**Guideline 1.3**). For instance, when a simpler layout is shown due to a weak Internet connection. Ideally, proper semantic markup differentiates headings, lists, and tables. Furthermore, navigation is intuitive, and instructions do not refer to visuals or sounds that might not be loaded.

Fourthly, users can easily distinguish foreground from background and orient in static and dynamic content (**Guideline 1.4**). That is achieved with multiple forms of conveying information – not only with colour. For example, in Image 4, WCAG authors put hyperlinks in blue but also underline them. When it comes to automatic audio playing for more than three seconds, it should be controllable from a webpage.

(Level AAA)

[Understanding Identify Purpose](#)  
[How to Meet Identify Purpose](#)

In content implemented using markup languages, the purpose of [User Interface Components](#), icons, and [regions](#) can be [programmatically determined](#).

Image 4. Example of information conveyed with colour and font

Compliance with the above-mentioned requirements is crucial to developing Perceivable and, ultimately, accessible webpages. Although the guidelines are of a basic level, they significantly contribute to positive user experience. People of any ability do not favour unstructured websites with unexpected noises, and these are the issues that a reader-developer can address now.

### 3.2.1.2 Level AA

The next level of accessibly presenting time-based media (**Guideline 1.2**) is to provide synchronised captions to live audio content (including, for instance, video conferences). Advanced adaptability (**Guideline 1.3**) is driven by responsive content orientation and identified purpose of each input field. Clarity must happen on a programmatical level, where fields collecting user information have defined autocomplete attributes such as in Image 3.

In terms of distinguishability (**Guideline 1.4**), the text to background contrast ratio needs to be at least 4,5:1. With 18pt-sized or bigger text and graphics, a 3:1 ratio is required. On the AA accessibility level, text content is resizable up to 200% without an assistive device, and line and word spacings are customisable too. The latter is achieved by using size definitions other than pixels. Additionally, Guideline 1.4 mentions content on mouse hover or keyboard focus. A user is able to dismiss appearing content, but it also stays displayed when the focus moves on it.

Standards for a Perceivable webpage focus on senses. The above-mentioned guidelines help everyone see, hear, and customise content following personal preferences. Furthermore, visual clarity unloads the cognitive burden.

### 3.2.2 How to make an Operable website

#### 3.2.2.1 Level A

First of all, all functionality of Operable webpages is available with a keyboard (**Guideline 2.1**). Nevertheless, mouse navigation is still encouraged. Requirement 2.1 is successfully met on a basic level also when keyboard traps are removed, so a user can freely manoeuvre through page elements.

Secondly, there is enough time granted to web visitors to read a page and interact with it (**Guideline 2.2**). Turn-off, extension, and adjustment of time limits are possible for non-live content. Similarly, all automatically appearing moving and auto-updating elements are controllable so that users can inspect parallel information. On Slack, for instance, a person can choose whether to see new messages or not (Image 5).

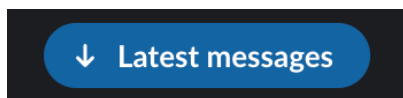


Image 5. Example of a user being in control of automatic updates

Thirdly, designers need to avoid solutions that are likely to provoke physical or seizure reactions (**Guideline 2.3**). These are big high-contrast flashes of more than three per second. Usage of red should be minimal.

Fourthly, navigation and search on a website are intuitive when Operability is embraced (**Guideline 2.4**). The methods include incorporating a “skip” button to omit repeated content,

making descriptive titles, and specifying the destination of each hyperlink with link text and/or context. Anti-example of the latter is a singular “[click here](#)”.

Fifthly, simpler non-keyboard alternatives to input methods are present on Operable websites (**Guideline 2.5**). Path-based gestures of swiping and drag-and-drop should have the same effect as a click of a nearby button. The same button recommendation refers to functions activated by the user and device movements. Down-events caused by a click or tap are discouraged.

### 3.2.2.2 Level AA

The level AA improvements exist only for orientation on a webpage (**Guideline 2.4**) and enhance the interplay between a human and web navigation. According to the criterion, a website has to adopt at least two methods of page search. These may range from a table of contents to a site search. Moreover, for easier orientation, the current location of a keyboard focus should be visible.

Already on the A level, the Operability principle resembles customer service, which a developer team ensures via a web entity. Users are given a choice, comfort, and control to make the most out of digital interaction. All the POUR principles but especially Operability unveil the value of designing with people in mind.

## 3.2.3 How to make an Understandable website

### 3.2.3.1 Level A

Firstly, for the readability of textual content, primarily, by assistive devices, the language of each page is marked (for instance, with `<html lang="en">`) (**Guideline 3.1**). Secondly, Understandable websites operate in a predictable manner (**Guideline 3.2**). Unexpected pop-ups or disorienting page changes are not supposed to happen either due to input inserted or keyboard focus change.

Thirdly, Understandable websites help users prevent and fix mistakes (**Guideline 3.3**). That is by explicit labels for user input such as in Image 3. If an error is spotted, it is highlighted, explained in text, and can be easily corrected.

### 3.2.3.2 Level AA

On the AA level, the predictability requirement (**Guideline 3.2**) concerns the remaining elements of a website. Objects that repeat throughout several pages (search bar, table of



contents) keep their look and location. In turn, proper input assistance (**Guideline 3.3**) results in suggestions for error correction (if security allows) and the ability to reverse and confirm sensitive data input such as of legal and financial details.

While perception competencies differ, cognitive activity is often the same among the middle-aged regardless of abilities. Therefore, it is important to make user interfaces understandable. Logic and clarity are the pillars of successful websites. Decorations come afterwards.

### 3.2.4 How to make a Robust website

#### 3.2.4.1 Level A

Robust websites are compatible with as many generations of assistive technologies and user agents as possible (**Guideline 4.1**). That is partly ensured by the absence of parsing errors. In other words, all markup elements have appropriate nesting, IDs and classes, and start and end tags. In addition to structural conformance, local values and properties are defined according to HTML specifications.

#### 3.2.4.2 Level AA

The next level of Robustness concerns informative status messages. Due to their unexpected nature, the notifications do not usually receive mouse or keyboard focus. However, a developer has to ensure assistive devices notice and announce status messages – usually via an ARIA alert.

Although the Robustness-related requirements are the last and shortest ones, they are the most crucial. If a website is Perceivable, Operable, and Understandable, but its HTML is uninterpretable for a user agent, partial compliance with the WCAG is of no help. The Robustness principle is a final touch that prepares a website to go live.

W3C recognises the fact that WCAG 2.1 can seem overwhelming at first. Therefore, the organisation has developed several supporting documents such as “Understanding WCAG 2.1” and “Techniques for WCAG 2.1”. The former clarifies the guidelines, and the latter accommodates multiple techniques, usage scenarios, and common mistakes. Noteworthy, if a website has a high aesthetic value, accessibility tradeoffs are acceptable but need to be declared and explained.

Chapter 3.2 explains the key technical characteristics of accessible web products and how the former are implemented. Thus, this section is central to answering the main research question. Having familiarised a reader with the essence of WCAG 2.1, the chapter unfolds its applicational significance throughout the report.

### 3.3 Theory of accessibility evaluation

Due to the dynamics of the web, proper evaluation of accessibility efforts should happen early and constantly. That is to track the impact of newer updates on the general accessibility of a website. There are three methods to detect flaws in presumably accessible interfaces: automated evaluation, expert review, and user testing. (Lazar et al. 2015, 157.)

Testing with potential users provides the most truthful insights on ease of use. However, the scope of the evaluation is limited to the ability level of the user group, so some interface issues may be unnoticed. Expert evaluation, on the contrary, struggles with communicating smaller matters that can only be discovered through manual use. Still, human expertise is unsurpassed in assessing compliance with legislation and standards on micro and macro levels. (Lazar et al. 2015, 161.)

Automated evaluation outperforms other options in terms of quantity but not quality. Tools can identify detectable features but cannot report whether they are used appropriately. Automated testing is best suited for trend analysis over numerous webpages and introduction to the web accessibility topic. For instance, evaluation tools build awareness of the management and inexperienced developers about their product. (Lazar et al. 2015, 171.)

Two of the thesis objectives are to evaluate the accessibility features of Brella and provide recommendations. Due to the novelty of the accessibility topic to the company, the author uses automated evaluation tools as a support means for analysis and further advice. The results of the two software tools endorsed by the accessibility community are examined in the empirical part of the report.

#### 3.3.1 Accessibility assessment tools

There is a wide selection of accessibility checkers. On the one hand, they all bring the same output highlighting problems and corresponding solutions. On the other hand, accessibility evaluation tools vary in price and trustworthiness since organisations from research centres to small audit agencies develop them. Another critical difference lies in the operational form that is most often either web-based or of a downloadable browser extension.

User experience with web-based software is the least resource-intensive. One does not need to download or install anything but can directly navigate to a selected assessment provider via a search engine. To launch the evaluation process, a user has to provide a link to the page or an HTML file that s/he wishes to examine. The output usually contains accessibility errors and alerts (potential errors that require manual verification), their location,

the name of a guideline violated, and the solution. As an example, AChecker, a revolutionary tool for its first release in 2005, still places high in software rankings (Digital Education Strategies, The Chang School 2019). AChecker has originated at the Inclusive Design Research Centre of the University of Toronto and enables assessment against both international standards and national laws such as Section 506 or the Italian Stanca Act (Image 6).

The screenshot shows the AChecker Web Accessibility Checker interface. At the top right is the AChecker logo. Below it is a navigation bar with 'URL', 'Upload', and 'Markup' tabs. The main content area is titled 'Check Accessibility By:' and contains a text input field with the URL 'https://www.brella.io/' and a 'Check it' button. Below this is an 'Options' section with three checkboxes: 'Enable HTML Validator', 'Enable CSS Validator', and 'Show Source'. The 'Guidelines to Check Against' section has radio buttons for BITV 1.0 (Level 2), WCAG 1.0 (Level A), WCAG 2.0 (Level A), Section 508, WCAG 1.0 (Level AA), WCAG 2.0 (Level AA) (selected), Stanca Act, WCAG 1.0 (Level AAA), and WCAG 2.0 (Level AAA). The 'Report Format' section has radio buttons for 'View by Guideline' (selected) and 'View by Line Number'.

Image 6. The user interface of AChecker

Browser extensions or plugins, on the other hand, must be downloaded as they expand browser functionality. As soon as an extension is installed, accessibility evaluation happens only in the browser. This allows to securely assess the accessibility of pages with sensitive information or authentication-protected web applications such as Brella. One of the popular browser-based accessibility checkers is Wave by WebAIM initiative at Institute for Disability Research, Policy, and Practice at Utah State University. Noteworthy, Wave provides visibility into errors and alerts by adding icons next to them (Image 7). The images are clickable and lead to error descriptions, the name of a WCAG standard disregarded, and fixing instructions. (Digital Education Strategies, The Chang School 2019.)

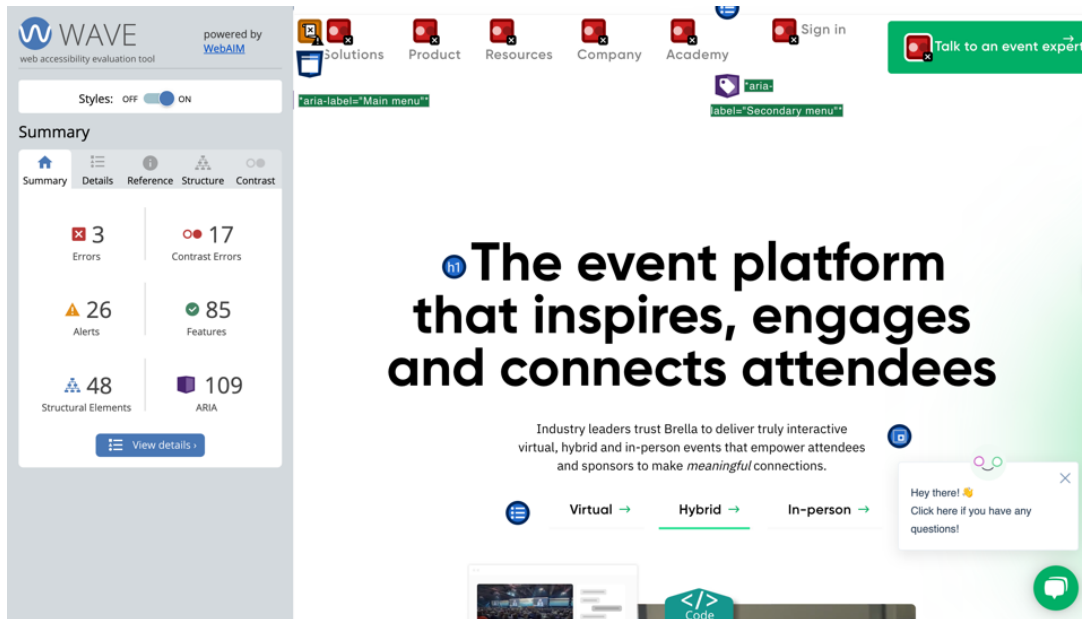


Image 7. The user interface of Wave

Another example of a browser-based accessibility reviewer is ARC Toolkit by TPGi. The organisation, previously named The Paciello Group, is a leading American accessibility solution provider, whose offerings range from UX services to audits. Furthermore, TPGi sells its ARC (Accessibility Resource Centre) Platform that connects, visualises, and supports all accessibility mechanisms of a business. (TPGi 2022a.)

ARC Toolkit is a different but integratable product. It is an accessibility testing tool focused on locating WCAG 2.1 level A and AA compliance failures (TPGi 2022b). The tool contains a default table of ARC rule engine assertions organised into categories (Image 8). A user can select and deselect categories for more structured work on individual web elements. For every group, ARC Toolkit communicates visible and hidden (critical for assistive devices) errors and alerts, if any. Selected singular errors are highlighted on the webpage assessed to demonstrate end-user experience.

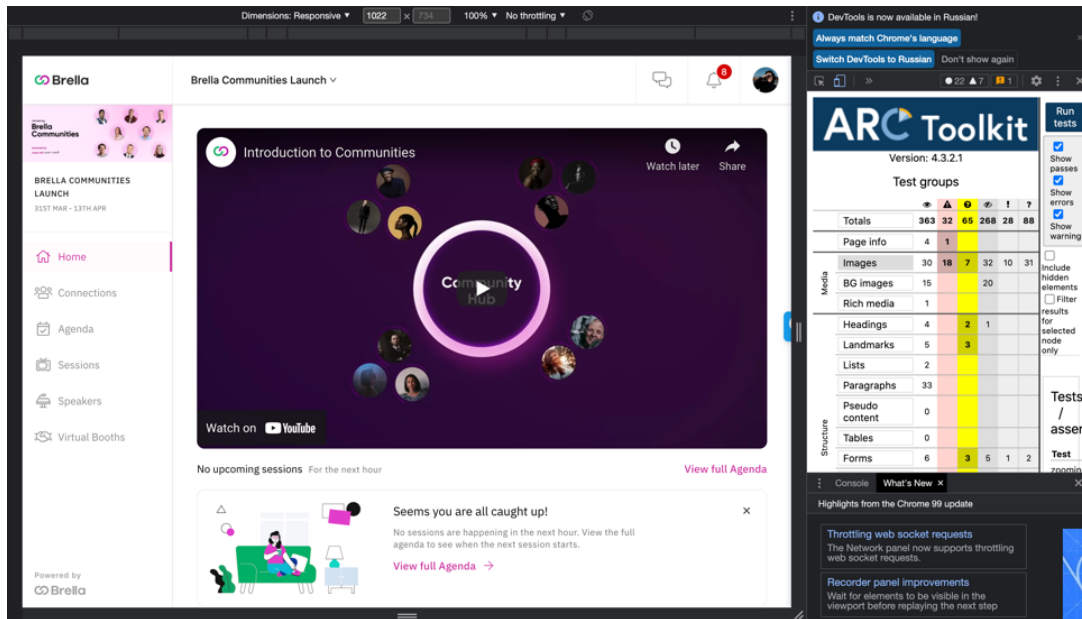


Image 8. The user interface of ARC Toolkit

As mentioned at the beginning of the report, Brella has a website and web application among web products. However, specifically the platform (or web application) is purchased by dozens of clients and used by hundreds of attendees annually. Matchmaking and networking happen on the platform. Therefore, the web application is analysed in the empirical part of the thesis. To enable automatic accessibility evaluation, the author utilises browser-based accessibility checkers.

### 3.4 Accessibility and good design

#### 3.4.1 Definition of good design

Good design has many interpretations. On the one hand, it is the one objectively assessed and acknowledged by professionals and awards (Heylighen & Bianchin 2013). Dieter Rams, a prominent industrial designer, is convinced that good design is embodied in aesthetic, innovative, and thoroughly made products, which again are evaluated by experts (Interaction Design Foundation b).

On the other hand, good design is a consequence of a decent design process. If methods and approaches utilised by creators aim for a quality result, then the expected outcome is likely to be reached. The study of Mehalik and Schunn (2006, 527) has gathered some of the most effective design process elements. They include problem exploration, iterative design strategy, and alternative solutions evaluation.

The third viewpoint is advocated by Min Wang, the Dean of School of Design at China Central Academy of Fine Arts. He believes benevolent and conducive to people concepts deserve the “good design” titles. (Berman 2008, 10.) Based on the above-mentioned, there are three perspectives on defining good design: the correspondence of a product to preset norms, the quality design process, and the attitude and attention of a creator to users.

The standpoints are hardly contradicting and rather form three foundational aspects of a potential definition. Hence, good design is a result of the thorough work of knowledgeable people, who are aware of the design art basics and actively follow changing industry standards. Especially in agile teams, designers are constant learners, so they know and apply the most effective methodologies to reach the desired outcome. The outcome itself is determined with an adequate understanding of the product's purpose, users, and context.

### 3.4.2 Interconnection between good design and accessibility

As stated in the chapter above, there is a connection between good and accessible design in terms of user consideration. Good designers are attentive to all users regardless of their ability level. Otherwise, UX discipline has to be renamed into Some User Experience (@thebillygregory 2015).

Architecture theorist Dana Cuff expresses an additional approach to good design. According to her (1992, 196), design quality depends solely on an assessor and his or her perception. From the point of view of Cuff, a building is excellent when architects, design assistants, and the public consider the construction excellent. Therefore, the more differing views arise in the design process, the better. The same logic applies to design and development in fields other than architecture.

Designers should involve diverse user groups in the process. Award-winning designers are likely to gather dust if their concepts regularly ignore product aims or client requests. Similarly, the wishes of people would stay unfeasible without being translated into the explicit language of professional design. (Heylighen & Bianchin 2013.) This is the point where standards and rules play an important role. They are not limitations but a skeleton to innovate on (League 2020). Therefore, accessibility and good design are interconnected: inclusion is at the heart of good design.

### 3.4.3 Combining good design and accessibility

The article of Heylighen and Bianchin (2013) recommends systematic integration of the needs of users in question into the professional design routine. In the case of accessibility, proactive communication between designers and people with disabilities ensures ongoing

information exchange and discussion. Computer researcher Lazar and his colleagues (2015, 75) explain why combining accessibility and good design principles should not be problematic. They encourage developers to be inspired by architects who strictly follow building code, which is the only way to construct with safety and accessibility. In the digital world, web standards are the building code for designers and developers.

### 3.5 Accessibility and customisation

Customisation places control over website content and layout in the hands of a user. When customisation is present, he or she can, for instance, enable a dark mode of a webpage and regulate text size – all with respect to personal needs. (Fritz 2018, 14.) Web Content Accessibility Guidelines 2.1 highlight namely visual customisation: adjustability of font, background, and size and colour attributes (W3C 2018). These are the exact features that the elderly participants of a survey by Ellis and Kurniawan (2000, 273) have emphasised.

Customisation enhances usability. With expandable text and an understandable font, one reads and finds target information faster when using devices even with small screens. The ability to adjust highly contrasting elements and general screen luminance helps users avoid visual fatigue. (Fritz 2018, 14.)

What concerns additional benefits, benevolent, caring UX is a powerful tool for nurturing customer loyalty through consistent satisfaction of needs. Once design and development with customisation in mind become habitual, the scope can increase via the collection and application of user feedback.

Customisation logic in web products sold B2B and used B2C seems to be more complex than when a customer is the user. That is because customisation functionality is provided directly to customers (businesses) to suit their branding and, thus, ensure rapid sales. Although Brella tries to consider all parties, including attendees, customisation tools are handed over to event organisers, who become responsible for accessible online event environments.

To guarantee pleasant experience to end-users, the company could limit the scope of features customisable by event organisers. This is the tactic today, where only two colours on the platform are changeable. In Image 9, these are green and purple. However, customers frequently request more customisable functionality.

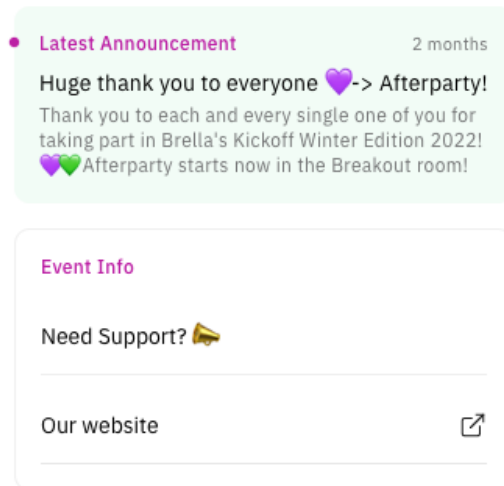


Image 9. Customisable colours on Brella

Responding to the customer feedback, the team could, on the contrary, increase the scope of customisation by introducing, for example, selectable fonts and word spacing parameters. To support appropriate usage of these, Customer Success managers could refer their clients to a pre-made accessibility guide from the Brella Help Centre. The guide would contain the best practices and recommended techniques for accessible customisation of the platform. For example, by highlighting the suggested contrast ratio if a corporate colour scheme is used for the background and text. Nevertheless, similarly to developers, event organisers have to involve attendees in the platform setting stage to craft the most welcoming environments for them.

The third variation of customisation strategy targets end-users alone. Customisation settings could be open and editable for every attendee. Such flexibility allows people to build the most comfortable event environments and gives the maximum of customisation opportunities. Noteworthy, accessible and responsive Brella may meet minor customisation needs of attendees in advance. Thus, for the team, prioritisation of accessibility over customisation may be more effective.

However, to support the atmosphere of a branded yet accessible event and serve the public with minimal customisation inquiries, organisers need to be in control of the visuals. This is the method to empower customers of Brella the most. Concerns of the company are understandable: people without experience in design may violate the accessibility of the platform. With maximised customisation opportunities, the responsibility for accessible online events becomes shared between Brella and the event team. Therefore, for Brella, providing satisfactory attendee experience involves not only the toolbox delivery to clients but also their



education. It undoubtedly takes time and effort but simultaneously drives relationships with customers to a higher level.

### 3.6 How accessibility is reached: application and summary

#### 3.6.1 Application of facts and theory to the design science project

The third chapter introduces several concepts significant for data collection and artefact development and, hence, recorded in the design science grid in Figure 8. Already in chapter 2.2, a reader learns about varying types of disabilities, which the Web Content Accessibility Guidelines target. In turn, accessibility evaluation tools often assess web products against namely the WCAG as standards acknowledged by national laws. Therefore, minimal familiarity with the guidelines is useful when interpreting the compliance score and feedback. Recognition by the international web development community has made the WCAG a core of any discussion linked to accessibility. For that reason, understanding WCAG terminology helps the author use the proper, professional language in the questionnaire.

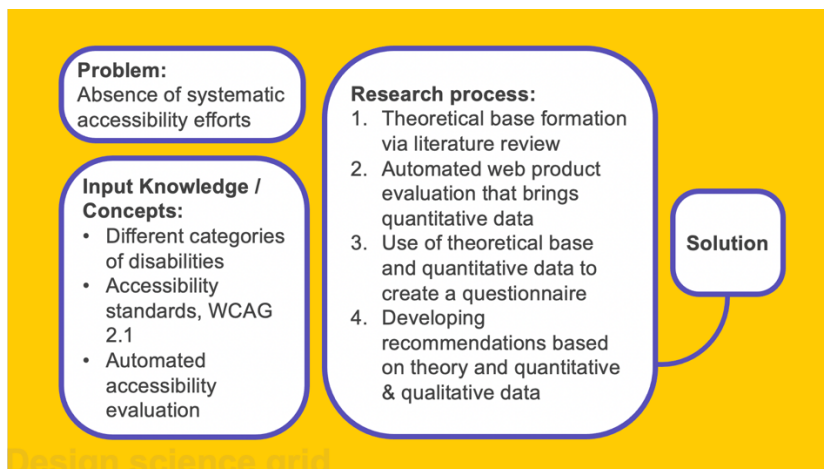


Figure 8. Design science grid, the third version

According to Figure 3, the final activity of the design science project within the thesis is artefact design and development. As defined in the research methodology, the target artefact of the study is methods (or recommendations). The next chapters document the empirical part of the research concluded with accessibility-improving recommendations.

### 3.6.2 Chapter summary

A skilled developer should not be torn between designing aesthetically and designing accessibly. Accessibility and good design are matching concepts, as creating with guidance from users is at the core of award-winning design. However, excellent combinations of the two do not take place effortlessly.

Accessibility is achieved through planned and consistent work with users. To support developers, the W3C has developed accessibility guidelines to promote Perceivable, Operable, Understandable, and Robust web products. Since feedback is a crucial element of development in any field, designers and developers are advised to evaluate work results early via testing with users, an expert, and/or special software.

In summation, the third chapter clarifies the how-questions regarding accessibility on the web and, hence, is more practical. It describes the characteristics of an accessible website and explains how to implement them. Therefore, the author of the report attains the corresponding objective and answers the main research question: what are the characteristics of an accessible website and how to implement them? In addition, the sub-questions on the compatibility of accessibility, design, and customisation are covered. Thus, all objectives and research questions affiliated with the theoretical part are now reached and responded to.

## 4 Automated accessibility assessment of the Brella platform

### 4.1 Platform introduction

The author conducted an automated evaluation of three pages: “Home”, “Connections”, and “Agenda” (depicted in Images 10, 11, and 12 correspondingly). The names are customisable, but the page content is always the same and described below. The pages were extracted from a free public event dedicated to the launch of Brella Communities, a brand-new engagement platform.

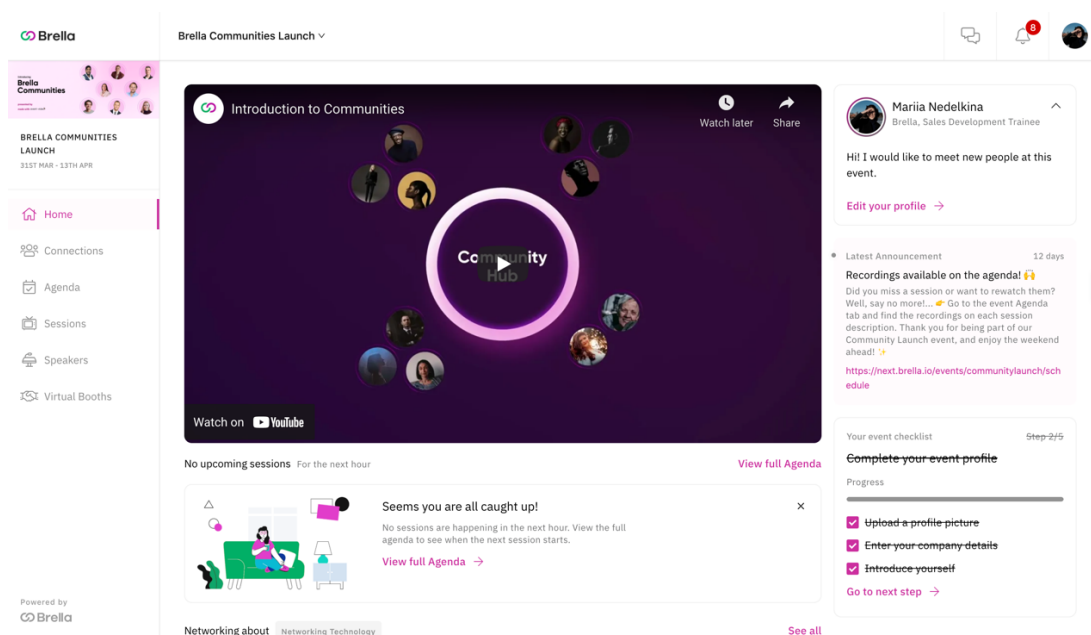


Image 10. Example of an event home page on Brella

After logging in and enabling relevant matchmaking settings, an attendee lands on the **home page** (Image 10). It is an intrinsic part of the user journey and, therefore, has to be accessible. Having a central location, a video, picture, or a media carousel welcomes visitors and encourages them to explore the event space. Noteworthy, Brella does not have an inbuilt streaming function, so video files and streaming itself are often embedded from YouTube. Since materials from the video hosting service are not playing automatically, this ensures absolute compliance with Guideline 2.2 (Pause, Stop, Hide) of WCAG 2.1. On the right, the home page shows a profile view, the latest announcements, and the event navigator.

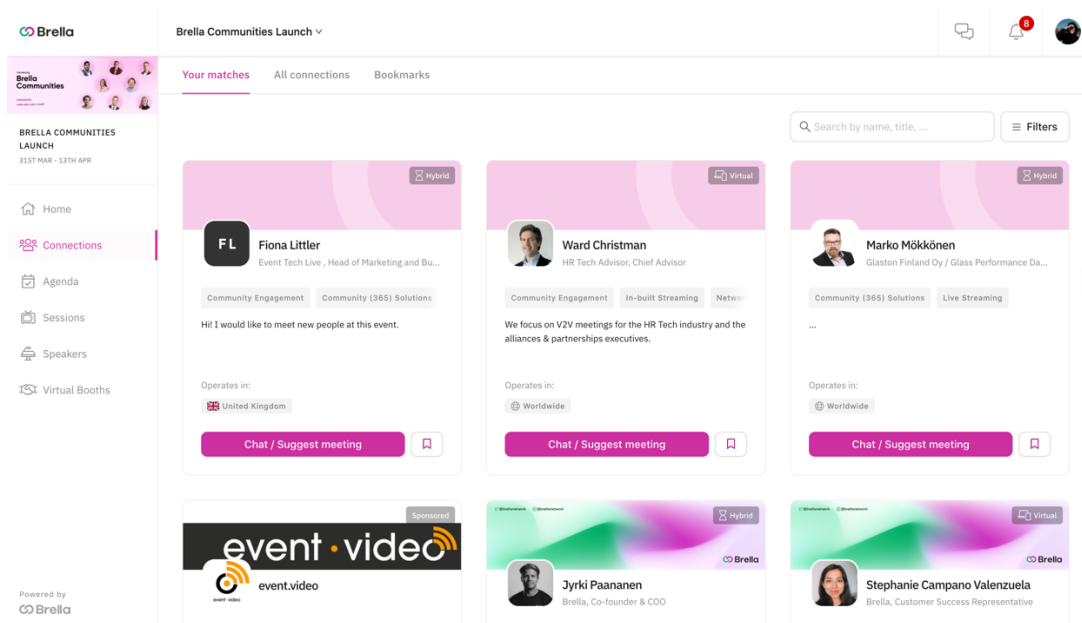


Image 11. Matchmaking page on Brella

“Connections” or the **matchmaking page** is unique (Image 11). Here, Brella brings all relevant people based on matchmaking intents one has selected in the beginning. The AI-powered matchmaking is often a deal facilitator at the selling stage and subsequently a meaningful part of events. Therefore, the maximal level of accessibility has to be present on the page. What concerns functionality, potential connections are displayed from the most to least suitable and can be bookmarked. Furthermore, Brella considers the time zones of participants when offering meeting slots and allows attendees to skip networking.

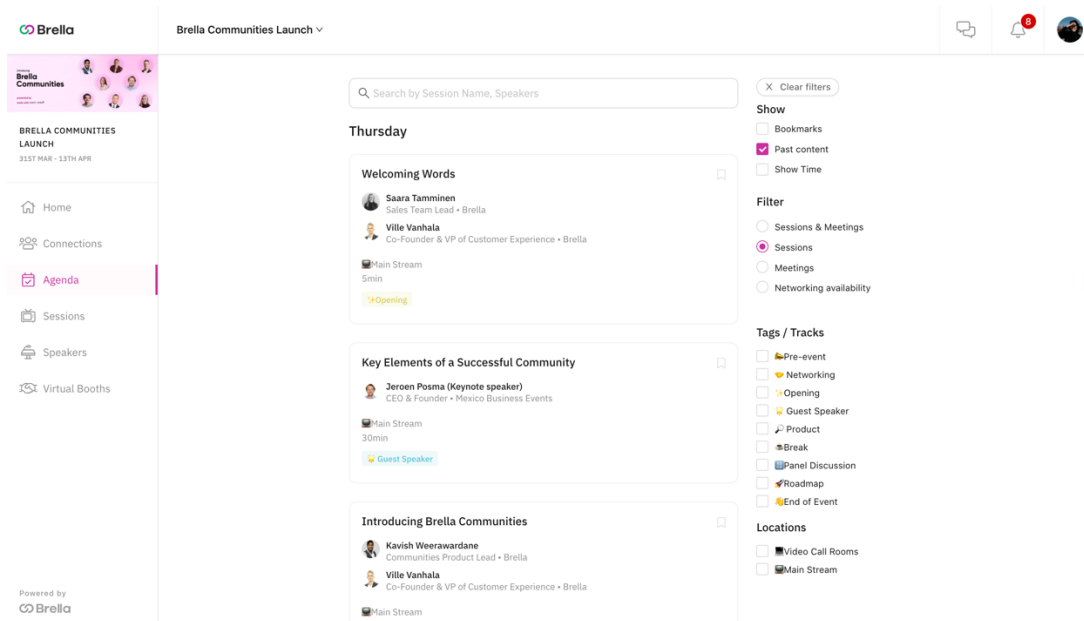


Image 12. Example of an event schedule on Brella

The final page analysed is “Agenda” or the **schedule page** (Image 12). It familiarises attendees with the timetable of an event and records planned individual meetings. The possibility to follow a general programme and own day plan should not be a privilege of participants without disabilities. Therefore, the author examined the accessibility of the given page to assure its inclusivity.

## 4.2 Assessment results

### 4.2.1 Brella from the perspective of Wave

Wave can identify six categories of web entities: errors, contrast errors, alerts, features (present accessibility-friendly markup practices), and structural and ARIA elements (Image 7). As the thesis follows the idea of design science or improvement research, the analysis focuses on detected errors (including contrast-related) and alerts. Wave has recognised the following **errors**:

1. The most frequent accessibility violation is very low contrast (41 unique contrast errors). According to WCAG 2.1, Guideline 1.4, the contrast ratio of small text to background must be at least 4,5:1 on Perceivable webpages. Wave has detected the compliance failure within grey body text on the home and agenda pages (Images 13 and 15) and matchmaking categories and professional titles on the matchmaking page (Image 14).

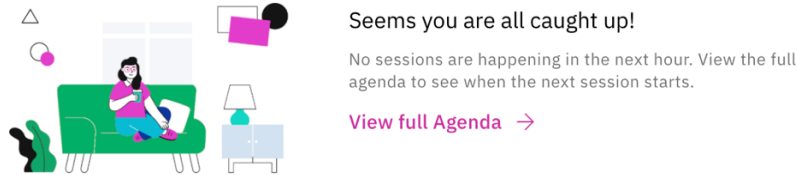


Image 13. User interface element on the home page

2. There are a couple of images missing alternative texts or alt attributes (two unique errors). The text representation of non-textual content is required by Guideline 1.1 of WCAG 2.1, one of the standards for Perceivable web. For instance, due to the absence of the alt attribute, the illustration in Image 13 is unavailable for screen readers.
3. The “Bookmark an attendee” button is empty or has no value text (one unique error that takes place within all 312 attendee profiles) (Image 14). Therefore, screen reader users are unable to perceive the button functionality and subsequently save favourable connections. The Guidelines that cover the issue are 1.1 of equivalent text alternatives and 2.4 (Operability part) of a clear link purpose.

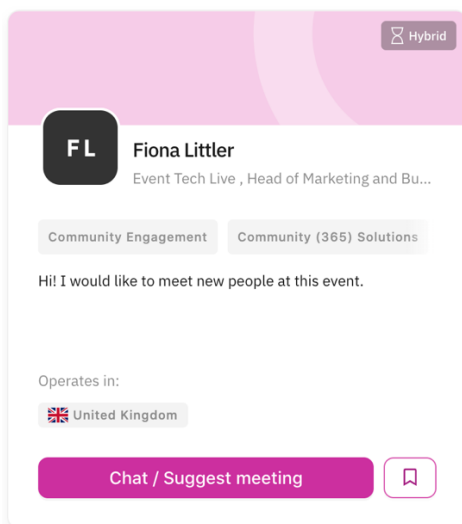


Image 14. Attendee profile on the matchmaking page

- The search bars on the schedule and matchmaking pages do not have form labels (two unique errors) (Image 15). Similarly to empty buttons, form controls without associated labels are incomprehensible for screen reader users. The Guidelines to consult are above-mentioned 1.1 and 1.3, which recommends the usage of text labels for form input elements for a better semantic structure.

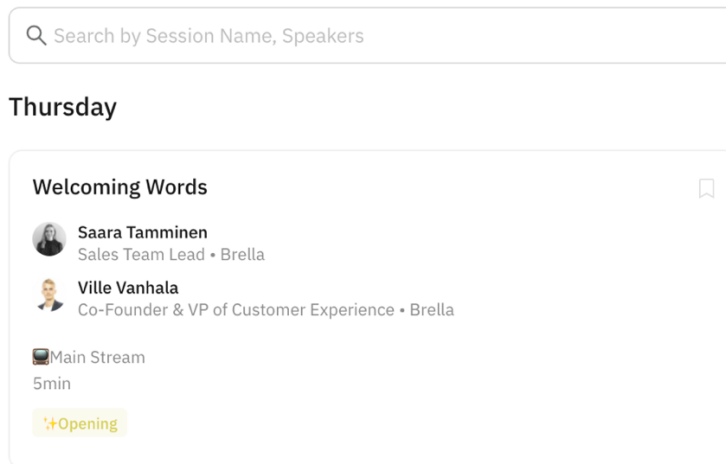


Image 15. A part of the event agenda

Wave has identified four types of systematic errors. On the one hand, it is not many and means a comparatively decent result achieved by a strong team of qualified front-end developers. On the other hand, about 46 different parts of Brella are marked as unperceivable. Three out of four error categories concern the markup of webpages, which are partly invisible to certain assistive devices and their users. The fourth error involves the visual distinguishability of text and, hence, impedes the perception of those who strongly rely on their vision when extracting information. Nevertheless, all the compliance failures are amendable, and Wave encourages and guides improvement actions.

In addition to errors, the author has organised **alerts** issued by Wave in the following manner:

- None of the pages has a first-level heading (<h1>). As a rule, the heading takes one HTML line but provides visual and semantic structure, which eases the page navigation for assistive technologies. Guideline 1.3 recommends maximising the mindful use of all available markup elements including <h1>.

2. The text of matchmaking categories and countries in attendee profiles is very small (Image 14). Although there is no supporting standard, tiny text in conjunction with low contrast makes information unreadable for participants with low vision.
3. The matchmaking section has redundant title text in page numbering (Image 16). In other words, the title attribute contains text identical to the actual or alternative text, whereas the attribute has to communicate advisory information. Despite the absence of a corresponding guideline, Wave suggests either deleting the attribute or inserting valuable information that appears on hover.



Image 16. Page numbering in the matchmaking section

4. Wave has noticed an embedded YouTube video on the home page and reminded of synchronised captions. They are required by Guideline 1.2 of WCAG 2.1 so that time-based media have alternative representation – in text. Subtitles automatically generated by YouTube may not be equivalent to audio and, therefore, have to be reviewed.

The mentioned alerts do not always rely on accessibility standards. Thus, there are web issues not covered by guidelines but significantly influencing accessible user experience. The errors and alerts emphasised by Wave were considered in the analysis of ARC Toolkit output.

#### 4.2.2 Brella from the perspective of ARC Toolkit

The evaluation output of the TPGi tool is less illustrative and has more details than that of Wave. Due to the accessibility focus, the developing company may have a more sophisticated target audience that needs an extensive overview of accessibility compliance for work projects. In addition to the table of ARC rule engine assertions, the software presents a test summary and numbered warnings and compliance failures (Image 17).



The screenshot displays the ARC Toolkit interface. On the left is a 'Test groups' summary table. The main area shows 'Tests / assertions' and 'Test results'.

Test groups	Passes	Errors	Warnings	Info	Failures
Totals	676	33	172	227	23
Page info	4	1			
Media					
Images	28	15	12	31	8
BG images	100			18	
Rich media	57				
Headings	5		2		
Landmarks	5		3		
Lists	2				
Paragraphs	32				
Pseudo content	0				
Structure					
Tables	0				
Forms	2	1		3	2
Frames	1			1	
Titles	10		2	15	5
Text formatting	0			2	2
Language	1				
Keyboard					
Links	21	14	25	1	11
Internal links	12	12	13		13
Buttons	9	1		31	5
Access keys	0				
Tabindex	8	1		6	1
Tab order	33				
ARIA UI	22		14	5	
ARIA live	1		2		

The 'Tests / assertions' table shows:

Test	Errors	Warnings	Group
missingHref	0	13	links
titleOnLink	0	1	links

The 'Test results' section shows four warnings related to missing href attributes on links:

- WARN**: `<a class="ant-dropdown-trigger css-rm2ylo ezuht54" style="background-color: #ffff00;">Highlighted</a>`. Text: Highlighted | Text From: link. Warning: missing href. WCAG 2.1 Success Criterion 2.1.1 Keyboard (A). Recommendation: If the link is interactive, add a valid href.
- WARN**: `<a class="css-rm2ylo ezuht54" style="background-color: #ffff00;">View full Schedule</a>`. Text: View full Schedule | Text From: link. Warning: missing href. WCAG 2.1 Success Criterion 2.1.1 Keyboard (A). Recommendation: If the link is interactive, add a valid href.
- WARN**: `<a class="css-x9oxf1 erfekt70" style="background-color: #ffff00;">See all</a>`. Text: See all | Text From: link. Warning: missing href. WCAG 2.1 Success Criterion 2.1.1 Keyboard (A). Recommendation: If the link is interactive, add a valid href.
- WARN**: `<a data-test="home-matches-card-link" class="etrv5ww2 css-cige7k erfekt70" style="background-color: #ffff00;">Suggest Meeting</a>`. Text: Suggest Meeting | Text From: link. Warning: missing href. WCAG 2.1 Success Criterion 2.1.1 Keyboard (A). Recommendation: If the link is interactive, add a valid href.

Image 17. Example of assessment output on ARC Toolkit

ARC Toolkit has proved the findings of Wave regarding low contrast, empty buttons, and missing alternative text. Nevertheless, there are several previously unnoticed faults discovered by the tool of TPGi. That is, for instance, via a unique “Tab order” visualisation feature, which represents keyboard user experience on a webpage in question.

With the function, the **error** of underdeveloped keyboard navigation was detected on all three pages (hence, three unique errors). According to Guideline 2.1 of WCAG 2.1, the functionality of Operable web products should be available using a keyboard. Many browsers support Tab as a key to change focus from one button or link to another (WebAIM 2022). However, a few links on Brella can be selected by tabbing. Image 18 shows that the side navigation panel is unreachable for keyboard users.

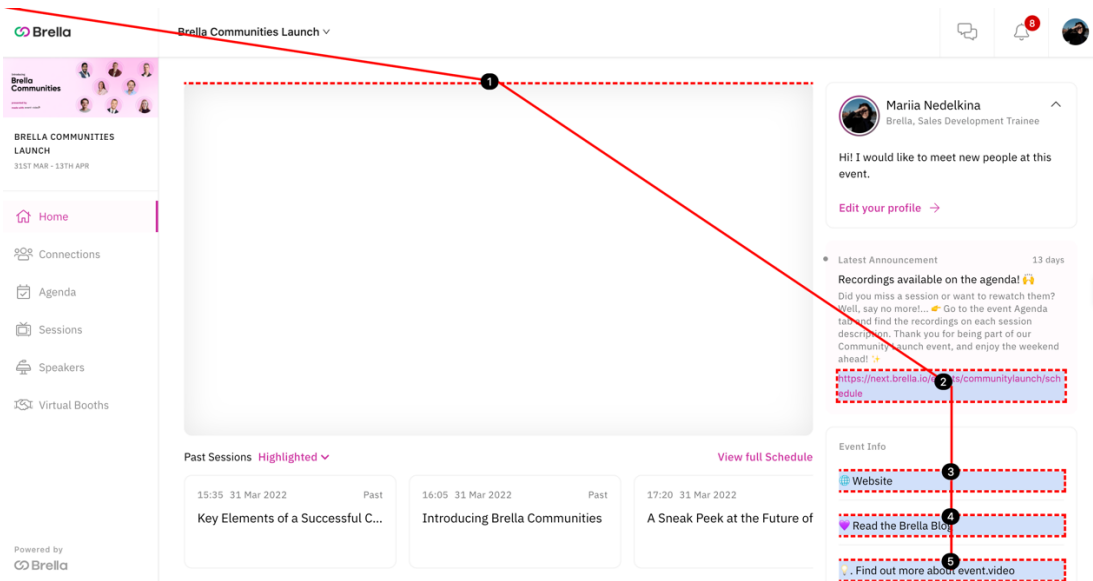


Image 18. Keyboard user journey on the home page

What concerns alerts, ARC Toolkit has delivered the following **warnings**:

1. None of the pages marks the main navigation links. Inserted with the `<nav>` element or `role="navigation"` attribute, the navigation landmark highlights a link group intended for website navigation. By locating a specified navigation section, screen readers communicate to users which links are important for website exploration. (MDN Web Docs 2022a.) In the case of Brella, the links under the event name on the left play the role of a navigation panel (Image 18).
2. Many links on the platform, for instance, “View full Agenda” and “Edit your profile” (Image 10), “Your matches” and “All connections” (Image 11) lack an href attribute. Similar links, without the attribute or with an empty one, are not accessible from a keyboard (WebAIM 2022). Therefore, they are not reachable with the Tab key nor depicted in the keyboard user flow in Image 18.

Despite the focus on compliance failures, Wave and ARC Toolkit also identify accessibility-friendly markup structures. The latter software has noticed the presence of aria-hidden attributes on different platform elements. The attribute does not affect the visual representation but technically hides content from assistive devices (MDN Web Docs 2022b). For instance, decorative icons such as in Image 19 are omitted so that assistive technologies process and transmit only informative content.

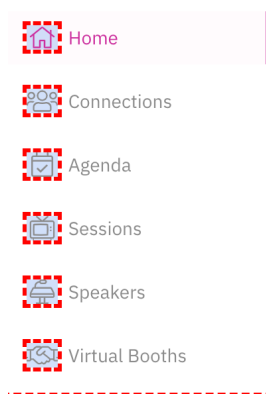


Image 19. Application of the aria-hidden attributes to icons

### 4.2.3 Assessment results: summary

In total, automated evaluation has found five types of accessibility compliance failures. They concern different guidelines and vary in frequency from happening once to 41 times. Moreover, the detected errors vary in effect: from the hardly keyboard-accessible platform to two ornamental images without alternative text.

The errors and alerts can be grouped into one list regardless of the inspecting software. For visual clarity, the points are ranged from flaws to warnings and from the most to least impactful. Thus, the following accessibility issues were discovered on Brella:

1. Weak keyboard navigation, no access to the menu for keyboard users
2. The very low contrast of the light-grey text to the background
3. Empty “Bookmark an attendee” button
4. Images missing alternative text
5. Input fields without form labels
6. Links without an href attribute
7. Very small grey text, for instance, on the agenda page
8. No navigation landmark on any of the pages
9. No first level heading on any of the pages
10. Redundant title text in page numbering on the matchmaking page
11. Non-live YouTube video missing synchronised captions.

As mentioned in chapter 3.3, automated evaluation tools help to start accessibility assessment efforts. Their strength is in quantity, not quality. Hence, the discovered errors may be less of faults with comments and context from developers. Automated evaluation traces flaws in the written code but rarely gives tailored improvement advice. Therefore, human checks are needed. Although carefully studied by the author, the discovered issues and further recommendations on their basis serve rather as a dialogue opener than a statement.

## 5 Learning about the views of the Brella team

### 5.1 Questionnaire design

Questionnaire design and distribution follow literature review and quantitative data collection in the adapted design science grid (Figure 8), and the order is deliberate. Literature examination has expanded the outlook of the author and familiarised her with the field basics, challenges, and topical terminology. These learnings help use proper language and ask relevant to research questions in the questionnaire. Preliminary knowledge of the product shortcomings, in turn, can highlight the interest of the author in the product improvement and initiate an honest discussion with the Brella team.

#### 5.1.1 Research sample

The research sample consists of the product team representatives at Brella. To assist in achieving the final objectives of the study, the questionnaire needs to address specialists who influence the final look of the platform. Therefore, designers and front-end developers are targeted.

The product team includes four designers and nine front-end developers (a total of 13). The duration of their experience at Brella varies from five months to six years. Thus, there are employees, specifically newly hired, who may be more open to embracing novel web accessibility practices.

Noteworthy, the product team follows the squad system of agile development, as it is divided into three cross-functional sub-teams of eight that deliver separate features. The chosen professionals work in different squads and, hence, have an impact on the accessibility of distinctive platform functionality. This fact proves the necessity of a generalised approach to stimulate inclusive software development.

#### 5.1.2 Ideation of questions

In general, the goal of the questionnaire is to learn how aware of accessibility the team is. Being knowledgeable, respondents can describe their successes or anonymously share areas of work that need improvement accessibility-wise. Furthermore, Brella employees may have mature ideas for more inclusive software that have not been previously heard. If findings indicate low topic awareness, the educational initiatives and training are to be the first and foremost recommendation to the company.

Bourke, Kirby & Doran (2016, 13) advise researchers to adhere to three golden rules of question design. Firstly, questions have to be comprehensible to respondents. Secondly, they should be able to answer the questions. Thirdly, a questionnaire has to be appealing and thought-provoking in general. In addition, Bourke and her colleagues (2016, 11) suggest focusing on simple and unambiguous questions without a negative or assumptive connotation. Considering the recommendations and busy schedules of the respondents, the author has produced the following questions:

1. Are you a designer or front-end developer?
2. How would you define accessibility? What do you know about it?
3. From your point of view, how well is Brella doing in terms of accessibility? 10 – amazingly well, 1 – it is an accessibility disaster.
4. How do you / how does your squad / how does the product team embrace accessibility nowadays, in day-to-day operations?
5. What are inaccessible design or development practices that you have noticed you follow / your squad / the product team follows?
6. Do you have ideas on how to change them to accessibility-friendly ones?
7. From your point of view, are there any barriers (e.g., lack of personal knowledge or supporting corporate standards) to systematic accessible software development at Brella as a company?
8. Weak keyboard navigation, low text to background contrast, and empty buttons are errors detected on Brella by automated accessibility evaluation. Do you consider these reasonable?
9. What would you recommend yourself / your squad / the product team to start doing to make Brella more accessible?
10. Any other comments?

There are no mandatory questions not to take much work time of the respondents. Questions mentioning “you / your squad / the product team” can be answered on any level that one feels confident discussing.

## 5.2 Questionnaire findings

### 5.2.1 Data acquisition process

The questionnaire was built on Google Forms. The target group received the link via Slack on 19 April 2022 and had four days to submit responses. The research topic caused many one-on-one conversations on the messenger. One of them led to a change in the research sample, as the only full-stack developer and quality assurance (QA) specialist at Brella were added to the target group. The workers correspond to the sample criteria: the full-stack developer works on front-end tasks, and the QA specialist has a final say in feature releases. Including their input, 11 out of 15 potential responses were received, which marked a 73% reply rate.

### 5.2.2 Analysis of the collected data

Answers to the **first question** communicate that two designers, eight front-end developers (including the full-stack development professional), and one QA specialist have filled in the form. Hence, the developer perspective prevails in the general Brella opinion on accessibility formed by the questionnaire responses. Then, for a start, respondents were asked to explain accessibility in their own words.

Everyone has managed to define accessibility when answering the **second question**, which is evidence of basic but solid knowledge of the topic. More than half of the respondents, six out of eleven, think that accessibility refers to the absence of obstacles to product usage. People with and without disabilities should be able to use Brella to its full extent on any device, the employees believe. Four respondents connected accessibility definition to the usability of a product to as many users as possible, and only one person limited the phenomenon to as required for people with certain disabilities. Noteworthy, two staff members highlighted the importance of HTML semantics, and one employee mentioned the WCAG. The exact wording of responses is presented in the word cloud in Figure 9. One can notice that “everyone” is one of the most frequently used words.



Figure 9. The word cloud of accessibility definitions given by the questionnaire respondents

As an answer to the **third question**, each interviewee rated the current performance of Brella in terms of accessibility on a scale from one to ten. The most popular score is three chosen by 27% of the respondents. The middle scores four, five, and six – each was selected twice. Thus, the majority notice accessibility-related shortcomings of the platform and software development process. The rest of the answers are depicted in Figure 10.

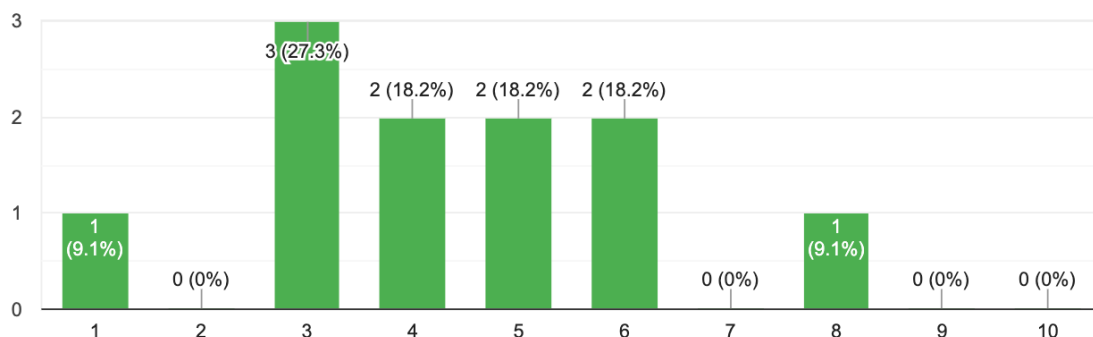


Figure 10. Ratings of the current accessibility performance of Brella



The **fourth question** has had a goal to unveil accessibility practices that the product team representatives follow now. Three respondents, who are seemingly involved in design, emphasise user interviews and extensive communication with clients in general. According to the QA specialist, she informs squads about such accessibility errors as low-contrast text or colour as a failure indicator. Nevertheless, four employees do not make any accessibility efforts nor see any attention to the topic from the management. Three professionals have slightly positive views: the conversations have started, but accessibility is not a priority. In case of time shortage, accessibility is compromised in favour of business needs. Additionally, one of the product team members reported the ignorance of his or her accessibility suggestions. All the received answers were analysed using the coding stripes method (Figure 11). As shown in the figure, the shares of accessible and inaccessible activities appear to be equal.

1. "Following guidelines by platform holders if available or using our inner standards"
  2. "Our squad has lately taken accessibility more into account. However, accessibility doesn't have high priority if compromises/shortcuts are needed or if it would take too much time."
  3. "We don't really put too much attention to accessibility at the moment."
  4. "We basically don't"
  5. "We don't really. We use some highlight colors for important areas, icons in buttons, etc. Really minimal stuff. One good thing is that we don't use too many different colors next to each other: our brand is basically just a lot of white with some brand colors sprinkled here and there."
  6. "We don't. Accessibility is least of the priority as most of the stuff is cut down from scope because of business's priorities these days. Also, we want to be "the generalist event app" where we do everything (including branding/customisation) which makes it very hard to follow the colour contrast guidelines as mentioned by WCAG"
  7. "Accessibility is a major concern when making any design and UX decisions. being inclusive and aware of the needs of your users"
  8. "We don't talk about it enough! There have been now some discussion about accessibility internally as a part of work experience and I do report any time when testing if I see that we are trying to use for example only colour as an indicator for success/failure or if we use elaborate animations or low contrast/small text. But web accessibility is not only about visual impairment. I'm planning to do a workshop about it."
  9. "I'm not really a part of these decisions. If anything, I feel that my suggestions were ignored"
  10. "We don't have talks about accessibility during project development or kick-off meetings, as an FE I only relay on designer"
  11. "Mostly by empathising the user, considering different use cases and interviewing end users."
- Conscious accessibility-friendly activities

Accessibility is acknowledged but not implemented

Accessibility is omitted

Figure 11. Coding stripes used to scan answers for accessibility-supporting activities

The **fifth question**, on the contrary, sought to uncover inaccessible software design and development practices. The absence of ARIA labels, dedicated testing against accessibility, and design concepts with tiny fonts – each was mentioned at least twice. In addition, there is a series of code-related observations such as little attention to web semantics, hardly generalisable “custom” code, and usage of a component library that convolutes DOM structures. One person underlines excessive platform orientation on right-handed users.

The **sixth question** aimed for inducing respondents to consider methods of change for the inaccessible practices that take place. Five out of ten answers contain concrete, problem-specific recommendations. Three of them are linked to design and include extended research, regular contrast and font size checks, and detailed concepts that could ease accessible feature implementation for developers. Two remaining answers suggest regular accessibility testing and the change of the component library. Another half of all replies present the solution in broader, high-level changes such as accessibility education and culture (mentioned by four respondents) and additional time allocation for accessibility improvement.

Answering the **seventh question**, the respondents shared their opinion on existing barriers to accessibility. The responses are generalised in Figure 12. Three employees are sure that the primary blocker lies in unawareness of accessibility components and misunderstanding of the scale of the problem. The common misperception is that few disabled attendees at best may need the platform. Two respondents find development costs, which are likely to grow due to additional layers of design, development, and testing, a stopper. Furthermore, the absence of associated requirements (business needs) from product managers or customers hinders accessibility-improving actions, two other respondents notice. One person considers the lack of written corporate guidelines a barrier. However, the report addresses that blocker and might become a preliminary solution.

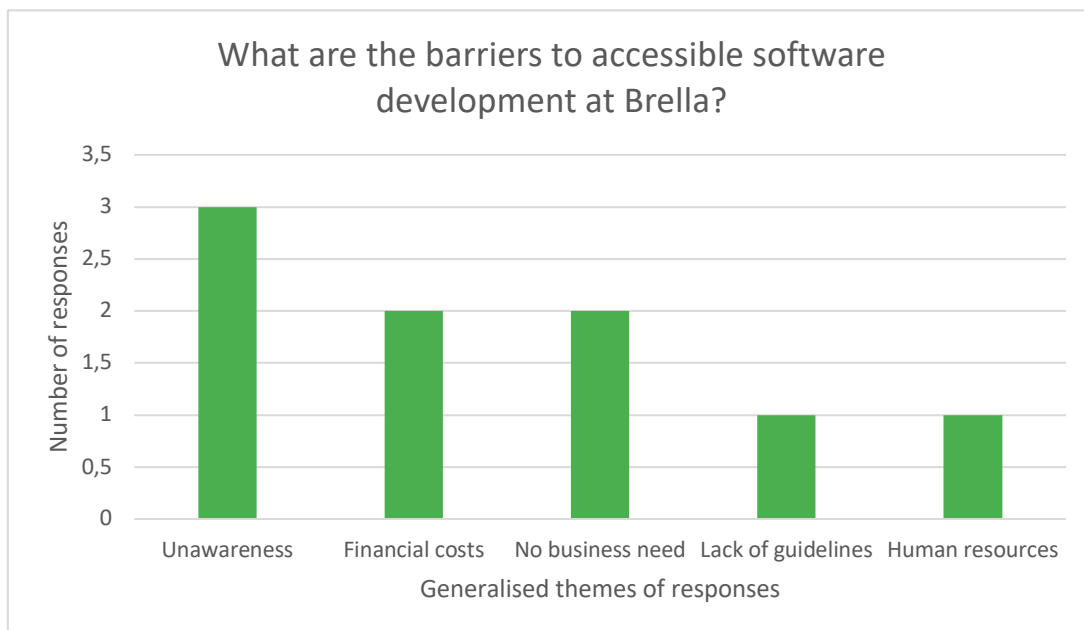


Figure 12. Accessibility blockers mentioned by respondents

With the **eighth question**, the author familiarised respondents with the three most impactful accessibility errors found via automated assessment and sought comments from the team. The goal was to receive any remarks admitting the faults or presenting counter-arguments. The comments and context were needed to validate the outcome of the automated accessibility evaluation. As a result, one response objected to the low contrast ratio on the design-end, and nine replies acknowledged the errors. One employee revealed that the issues had been known but differing priorities had left no time for corrections. Therefore, automated accessibility assessment results are trustworthy.

In the answer field of the ninth **question**, each respondent could leave a recommendation to him/herself or the whole team to encourage accessible software development. The suggestions involve discussions with product managers on priorities for the product team and general nurturing of accessibility culture. Respondents believe in the power of education but are convinced that actions must follow: regular accessibility audits via accessibility checking tools and adherence to defined design and development standards.

### 5.2.3 Summary of the findings

While the responses themselves are attached to the report as Appendix 1, the following conclusions arise on their basis:

- Brella designers and developers know what accessibility is. However, as some employees highlight their basic knowledge, the chapters on the theory of accessibility and standards make the report a beneficial educational resource. It can deepen understanding and align individual awareness levels.
- There is room for accessibility improvement at all software development stages: design, production, and testing. Respondents mention client interviews and extended conversations, but they are usually conducted with event organisers rather than visitors. Thus, the spectrum of attendee representation is narrow. Also, despite being initially overlooked by the author, testing drastically influences product inclusivity.
- The change of attitude is key to accessible Brella. There should be a common understanding of why accessibility is not limited to the disabled.
- People know about the platform and development process flaws and have correction ideas. Thus, the role of the author narrows to of a change facilitator and partly an educator.

Several responses mention the lack of written accessibility guidelines, which highlights the potential value of the thesis and report to the team. The author realised another omission

in the target group designation when reflecting on the findings – product managers. The company has two of them, and they define product development strategy and indirectly influence the final look of Brella. Nevertheless, this mistake can be revised in further research.

The last answer field in the questionnaire had no subject and was open to comments and ideas. A few people suggested sharing the responses with the technical management of the company, and the suggestion was implemented due to anonymised answers with viable improvement ideas. Noteworthy, when the questionnaire was out, one event attendee made a post on LinkedIn about an accessibility error (non-resizable text) that had not let her enter an event on Brella. In turn, the marketing department apologised for the inconvenience and communicated the issue to the product team. The author regards these two simultaneous events, the questionnaire and post receipt, as potential incentives for the technical management of Brella.

## 6 Accessibility-improving recommendations

As Figure 8 suggests, the final phase of the design science research is recommendation formation. Moreover, the result of the research stage is a target artefact of the project. The chapter accumulates discoveries made through literature review and data collection in a step-by-step applicable form. The section serves as a logical conclusion to the report but also brings value as a standalone list of recommendations.

The path to accessibility is resource-intensive from the perspectives of time and money. However, it eventually converts into benefits for both users and developers: ease of use on the one hand and satisfaction from working with socially important development methods on the other hand. The product team members recognise the current problems and have correction ideas, but the green light has to come from the management. If C-level executives realise the benefits of accessibility, they could start implementing it by doing the following:

1. Start nurturing the culture of digital empathy, where accessibility is known, discussed, and prioritised. The technical management has to initiate that but actively involve employees. Establish responsibilities, for instance, by assigning project owners.
2. To prioritise wisely, find the balance between accessibility and business needs in terms of functionality and time allocated. For instance, a developer could spend 70% of his or her work week coding features, 20% – refactoring, and 10%– doing accessibility examination of the code. The recommendation is among the first ones as an early start makes a difference. With the above-mentioned LinkedIn post, accessibility has already become a business need and is likely to become enforced by law in the future.
3. Learn from your personnel and embrace peer-learning. The team should be heard: Brella employees know the weaknesses of the platform and understand how to revise them. Knowledgeable designers and developers can set a baseline for accessibility initiatives. Furthermore, company-wide accessibility standards can also be generated as a result of joint efforts of the product team and its management.
4. Make individual awareness levels concur by educating the product team, for instance, with a series of workshops. The report can be utilised as a pre-reading material or referred to in presentations. The sessions themselves need to mention why accessibility eases the lives of everyone and present examples.

5. Start consulting accessibility straight away by auditing every new feature via accessibility checkers. After it becomes a habit, the team can begin eliminating the technical debt.
6. As for design, fix the related issues identified by automated evaluation such as small low-contrast text. In addition, start diversifying design research by connecting to attendees of varying backgrounds. Incorporate contrast and font checkers into a designer toolbox and promote them.
7. When it comes to software development itself, eliminate the front-end errors highlighted by the accessibility checking tools. Emphasise the importance of accessibility standards and proper code semantics in particular. Resort to reliable component libraries by studying their side effects first.
8. Introduce dedicated testing against accessibility.
9. Document the accessibility-supporting standards and procedures for the team to rigorously follow and new employee onboarding.

## 7 Conclusion

According to Figure 3, the design science project has reached its last stage – artefact design and development. Therefore, conclusions about the work performed can be drawn. To begin with, the thesis has attained its objectives:

- The report defines accessibility and describes its connection to usability and inclusion. In addition, the theoretical part explains why accessibility is important and what impedes it.
- The academic work familiarises a reader with different approaches to accessibility implementation starting from cooperation with professional consultants to automatic audits of products against accessibility. The core component of the process is adherence to the accessibility guidelines that help developers address web elements one at a time.
- The thesis project evaluates the performance of the Brella platform in terms of accessibility and uses the theoretical framework to interpret the results. Two automated tools have been used to assess the platform.
- The survey of the Brella product team is a part of the thesis. Respondents have expressed their views on accessibility and given comments on issues identified by the auditing software.
- The project is finalised with a list of recommendations, which are grounded on questionnaire responses, results of automated evaluation, and theories. The suggestions can be implemented straight away and aim for drawing attention to accessibility at the company.

Being categorised as applied research, the thesis has also had an unspoken objective – facilitating change at the company. The questionnaire results have been shared with the technical management, and the Theseus link to the report is to be communicated too. The deliverables explain the problem, immediately offer a solution, and, thus, may incite managerial staff to act. In addition to potentially bringing business value, the thesis has had significant educational effects on the author.

### 7.1 Answers to the research questions

Throughout the thesis, the following answers to the research questions have emerged:

**What are the characteristics of an accessible web product and how to implement them?** (Main research question)

Accessible web products are characterised as Perceivable, Operable, Understandable, and Robust. To accommodate all these features, web content and functionality have to be interpretable through any sense available to a person, reachable through any navigation method, and matching different levels of human cognition and technology novelty correspondingly. Product transformation from zero to totally accessible is covered in the latest international standards such as WCAG 2.1, which can be followed step by step.

Although adherence to standards makes a product formally compliant, a website may hardly bring value to the disabled because of a minor accessibility shortcoming in the user flow (for instance, on the login page). Therefore, the input of users with disabilities should be utilised at every stage of product creation: from design to QA and from user interviews to test cases. These operations are done naturally with the attitude that regards accessible software development as the only way to improve web products for everyone. In other words, accessible web products start with open-minded teams. Then come standards.

### **How to make a website/web application inclusive by means other than accessibility?**

Indeed, accessibility is one aspect of inclusion. There are several other ways to make an inclusive web product:

- To enable access to it from any geographic location
- To generate content comprehensible to people with different cultural and educational backgrounds
- To develop features usable by representatives of different levels of computer literacy
- To adapt it to hardware, software, and Internet connection of varying quality.

### **Are accessibility and proper professional, academically acknowledged design complimentary or contradicting concepts? If they are matching, how to combine both?**

Accessibility and proper professional design are matching concepts. The abilities to hear customers, realise their needs, and meet them in a product are the qualities of professional designers. However, customers are different, and specialists, who design with empathy and value in mind, serve them best by not separating accessible from good. Ideally, heterogeneous design research and accessibility-friendly prototypes have to be an intrinsic part of any design routine.

### **With an accessible and well-designed app, how to give the maximum of customisation opportunities to customers/users?**



In conversations about accessibility, from the perspective of an attendee, the most generous customisation opportunities mean freedom in adjusting platform layout to personal needs. Technically, the corresponding tools have to be planned, designed, and coded. However, accessible Brella may meet minor individual customisation needs in advance. Therefore, if taken into production, accessibility has to be addressed first. From a customer point of view, customisation is needed to support the branding of an event. Requesting it for more than a year, Brella clients need the customisation mechanisms as well as guidance on how to use them wisely and in an accessibility-supporting manner.

## 7.2 Validity and reliability

Reliability refers to the consistency and replicability of research findings. It is assessed by evaluating measurement results from different parts of collected data, at varying times, or by different researchers. (Middleton 2019.) Two latter assessment types are unreachable under the current research scope, but internal consistency of measurement results is examinable. Generally, quantitative and qualitative data collection processes have aimed for studying two perspectives on the accessibility of Brella – of software and humans. Both have concurred that there is room for platform improvement in terms of accessibility. Thus, research performed as a part of the thesis project is reliable.

Research validity, accuracy of measurements, has been ensured by planning the data collection methods, questionnaire sample, and questions themselves. In addition, the findings correspond to the theoretical framework of the thesis, which is another sign of validity. For instance, platform shortcomings mentioned by the questionnaire respondents are direct consequences of accessibility standards ignorance. Hence, the research appears to be both reliable and valid.

## 7.3 Suggestions for further research

As a comparison, examples of the most accessible web applications can be added to the extended report and analysed. For higher relevance, the examples can be researched among competitors of Brella. With deeper knowledge about accessibility, the author could do a manual audit of the platform and suggest features that could enhance accessibility compliance of the company. Moreover, the researcher can investigate the most widespread disabilities of Brella attendees (for example, with a questionnaire distributed externally with the help of the marketing team) and propose corresponding solutions. In case of numerous visible additions, a prototype of the renewed platform could be developed. Next internal data collection rounds may have more detailed questions sent to a bigger target group – for instance, the whole product team. Further research could also follow behavioural science

rather than design science and focus on changing the behavioural patterns of the developers and designers at Brella.

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## Appendix 1. Questionnaire responses

	1. Who are you?	2. How would you define accessibility? What do you know about it?	3. From your point of view, how well is Brella doing in terms of accessibility?	4. How do you / how does your squad / how does the product team embrace accessibility nowadays, in day-to-day operations?	5. What are inaccessible design or development practices that you have noticed you follow / your squad / the product team follows?	6. Do you have ideas on how to change them to accessibility-friendly ones?	7. From your point of view, are there any barriers (e.g., lack of personal knowledge or supporting corporate standards) to systematic accessible software development at Brella as a company?	8. Weak keyboard navigation, low text to background contrast, and empty buttons are errors detected on Brella by automated accessibility evaluation. Do you consider these reasonable? Why?	9. What would you recommend yourself / your squad / the product team to start doing to make Brella more accessible?	10. Any other comments?
1	Front-end developer	Making apps equally available for everyone without any "obstacles"	6	Following guidelines by platform holders if available or using our inner standards	Sometimes "custom" code creates implications for making the final product more accessible	Educate developers on the topic and create development culture	No idea :/	Absolutely	Culture and development practices	None
3	Front-end developer	I would define accessibility as something that makes the product usable to as many people as possible. I think I know the basic concepts about it but I don't feel as expert.	5	Our squad has lately taken accessibility more into account. However, accessibility doesn't have high priority if compromises/shortcuts are needed or if it would take too much time.	Clickable elements are possible (divs). Text contrasts or size not big enough everywhere. Few places have possible annoying animations that cannot be turned off.	Should make all clickable elements as buttons or links. Should use a contrast checker when designing. Should check if browser prefers reduced motion.	I'm not sure. Maybe we should have some a written guideline how accessibility should be taken into account.	Yes, I do. Those are good examples of the basic accessibility issues which should be fixed.	Written guideline. Automatic a11y CI checking. Good sources where you can learn more about a11y if needed.	Thanks for rising the importance of accessibility! I believe that accessibility is something all developers would like to take more into account. I guess, that a11y issues are not easy to spot by developers who don't naturally face the issues themselves or doesn't have strong passion/knowledge about a11y. However, the situation should get better by automating and educating.
4	Front-end developer	In Brella's case, anyone could access and use Brella's applications including people with disabilities.	5	We don't really put too much attention to accessibility at the moment.	We don't really have any practices.	Yes, I know how to make apps more accessible but it takes time.	I think the requirement (business need) for this should come from product management / customers but I haven't heard of any requirements.	Yes, those are reasonable for example for people with disabilities with eye sight. Without those they cannot use Brella properly.	First, I think we should have a discussion about this with product management. I think accessibility is important but I'm not the one (at least not alone) who makes business decisions about this.	This is important topic to bring to people's awareness.
5	Front-end developer	The app should be usable for people with certain disabilities. So in web applications it means that it should follow semantic HTML practices so screen readers / other tools can read it, and that the design should have easy to read fonts and colors.	3	We basically don't	We use this component library that makes very convoluted DOM structures, I'd think it's not very good for accessibility and we don't really make use of aria-labels and such. Not sure about the design side of things. We also don't really test for accessibility.	We'll the component library could be changed to a different accessible one or we could just not use a component library and test the app for accessibility in the development cycle if we'd want to make it a priority.	We'd have to change the dev processes to take accessibility into account so that's a huge effort in itself and it would cost the company a bit more since it would introduce another layer of development and testing to take accessibility into account. I think the barrier is cost of development.	Yes, makes sense that there those kind of problems in the web app since we don't really take accessibility into account in our development.	If we'd want to make it a priority, we could enforce accessibility audits in the dev process, so we'd have to make new features as accessible as possible.	
1	1. Who are you?									
6	Front-end developer	Mainly I'd define accessibility to be something that is as usable and accessible by everyone with a disability than those who don't. And then some: accessibility can also mean that something is e.g. accessible and usable on all mobile devices via the mobile browsers.  It's a vast topic which contains a lot of things to consider all the way from design and research stages to the actual implementation. Accessibility also changes based on the media: accessibility on the Web is much different than accessibility on some physical devices. I'm know of WCAG, however I'm not aware of all the criterias it entails.	3	We don't really. We use some highlight colors for important areas, icons in buttons, etc. Really minimal stuff. One good thing is that we don't use too many different colors next to each other: our brand is basically just a lot of white with some brand colors sprinkled here and there.	Super tiny text (this truly baffles me, I don't understand why everything has to be made so freaking tiny and in a way that it doesn't grow on bigger resolutions), no responsive design/implementation, green and red colors literally next to each other, improper contrasts on button background and text colors, no ARIA labels or other attributes on the elements in our Web App, etc.	Start actually bringing accessibility on the table. Educate everyone about accessibility. Challenge the idea of continuing with the tiny texts. Ask designers to think about responsive design, and developers to responsive implementation. Think how the Web App could be used with a keyboard.  All in all, it's a big task to begin with, and only changing our attitude and mindset towards accessibility is the key to fix things. Sure we can add ARIA labels here and there, and make some components more responsive, however, we still need to see the bigger picture and define steps how to achieve a good accessibility on our platform.	I don't think there are any major blockers to allow us to improve the accessibility of our platform. I think it's mainly a priority issue and something that people don't see that important to cover in our work.	These are 100% true and reasonable. We haven't taken any of these things into consideration in our work.	Educate people about accessibility. See which are low hanging fruits and deal with those. Define what are the main criterias we want to satisfy in the guideline. Make our Web App more responsive. Actually dedicate time to do all this.	Awesome to see you pick accessibility and Brella as your thesis topic! It's an important topic and we really should start thinking about this stuff at Brella. Please share the questionnaire results to the tech management!

1. Who are you?	2. How would you define accessibility? What do you know about it?	3. From your point of view, how well is Brella doing in terms of accessibility?	4. How do you / how does your squad / how does the product team embrace accessibility nowadays, in day-to-day operations?	5. What are inaccessible design or development practices that you have noticed you follow / your squad / the product team follows?	6. Do you have ideas on how to change them to accessibility-friendly ones?	7. From your point of view, are there any barriers (e.g., lack of personal knowledge or supporting corporate standards) to systematic accessible software development at Brella as a company?	8. Weak keyboard navigation, low text to background contrast, and empty buttons are errors detected on Brella by automated accessibility evaluation. Do you consider these reasonable? Why?	9. What would you recommend yourself / your squad / the product team to start doing to make Brella more accessible?	10. Any other comments?
7	Designer	1	We dont :) Accessibility is least of the priority as most of the stuff is cut down from scope because of business's priorities these days. Also, we want to be "the generalist event app" where we do everything (including branding/customisation) which makes it very hard to follow the colour contrast guidelines as mentioned by WCAG	Its not much about what we follow. I dont think any squad wants to make product inaccessible. Its what we prioritise as business and the team.	Design system is a first step. When we create elements in design system with all the accessibility features (as simple as using alt text in images), we can scale to make Brella accessibility friendly.	Business outlook to the issue. Lack of awareness. The classic "That only affects X% of our users so why bother for it"	I dont understand the question well. I can give you context - atleast for colours, we use a simple palette for things that are in our control (and they have proper contrast ratio), however, because Brella wants to be a white-label kind of solution, the theme customisation makes it difficult to produce good contrast (as organiser can chose any colour as primary and secondary -- and business doesnt allow the teams to adjust the colour to match accessibility, they prefer to use exact hex codes)	Have some design/development standards that you stick to no matter what.	
8	Front-end developer	6	Accessibility refers to a practice of making my digital content accessible to as many people as possible, ease of use and a better UX.	Accessibility is a major concern when making any design and UX decisions, being inclusive and aware of the needs of your users.	Some buttons and designs are outdated and hard to use	Human resources!!	I think those are important issues, and known issues, but they have not been prioritised yet for many reasons.	Nope!	
9		3	We dont talk about it enough! There have been now some discussion about accessibility internally as a part of work experience and I do report any time when testing if I see that we are trying to use for example only colour as an indicator for success/failure or if we use elaborate animations or low contrast/small text. But web accessibility is not only about visual impairment. I'm planning to do a workshop about it.	We don't take into account different font sizes, it's impossible to navigate without the mouse or with a screen reader, images don't always have text etc.	We should start following the general guidelines about accessibility and people are probably not aware of all the different aspects, which is why I wanted to do a workshop where we try to use our website simulating different disabilities and also talk about all the different types of disabilities, whether permanent or temporary.	Mainly lack of understanding the scale of accessibility. Many people think it's only about colour blindness and total blindness and that there is a very limited number of these users, so it doesn't get priority.	Yes! Accessibility allows all our potential users to actually get something out of our platform. Empty button -> missing functionality, weak keyboard navigation -> not possible to see all content, low contrast -> missing information	Run for example Chrome lighthouse for all new features to make sure there are no high prio violations and when we are used to it, start working on tech debt. Thank you for doing this, maybe I can talk to you about the a11y presentation when I have finally time to focus on it?	

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10	Front-end developer	4	Broadly - removing barriers in user experience. Also, it encompasses using semantic web to allow people with disabilities to consume content. However, we do not really support it at Brella here.	I'm not really a part of these decisions. If anything, I feel that my suggestions were ignored.	No attention to semantic web. Interface bloating that makes features hard to find.	Yes, absolutely - it requires investment and it's often not warranted from the business perspective.	I think this is fair. We didn't pay much attention to it, it was pretty much never a part of the spec.	Explicitly discuss how far it makes sense to go for us, and then uphold such a standard. Good luck with you project :)	
11	Front-end developer	4	Accessibility means for me that everybody can use the platform/page even if you have handicapped.	We don't have talks about accessibility during project development or kick-off meetings, as an FE I only relay on designer	Everything is designed for right-handed users, no help for blind users. Using large/clear fonts, help/guide tips in the UI, responsiveness, customisation options.	The main issue is that people doesn't even realise how inaccessible the platform is and in what ways is it inaccessible, as this is not an every day problem for the most of us this is something what we need to learn.	First of all we would need a workshop to understand what accessible means (quite honestly I'm not even sure what are the biggest issues and how this affects other users) and what it means for Brella customers. If everybody will be on the same page of what are the most problematic parts of the platform the improvement will be much faster.		
12	Designer	8	Delivering the same or similar experience to every human being despite the conditions.	Mostly by empathising different use cases and interviewing end users.	The key would be to build empathy within teams.	Technically may be, but not a hard blocker in my opinion.	Yes. These are some of the key elements to determine if a product is accessible by the most.	Building our own design system. Which is in the progress. You rock Maria! 🙌 All the best!	