Accessible EU Report
Digital Accessibility

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EASPD

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0. Executive summary

The purpose of this document is to transfer knowledge in the field of accessibility in ICT. Since this is a fast-paced area that is subject to constant innovation, a large number of links have been provided in this document in addition to explanations in order to ensure a certain topicality throughout the entire project period and beyond.

In our information society, traditional notions of normality and abnormality are becoming increasingly obsolete, as individual differences and diverse needs become more widely recognized and appreciated. By designing and building our systems and services in that new understanding, we can cultivate a culture of inclusivity that transcends traditional distinctions based on ability or disability.

1. Abbreviations und Acronyms

- **ADA** Americans with Disabilities Act
- **AR** Augmented Reality
- **AT** Assistive Technology
- **ATAG** Authoring Tool Accessibility Guidelines
- **ATM** Automated Teller Machine
- **BCI** Brain-Computer Interface
- **BITV** Barrierefreie Informationstechnik-Verordnung
  i.e. "Accessible Information Technology Regulation"
- **CEN** European Committee for Standardization
- **CENELEC** European Committee for Electronical Standardization
- **CRPD** Convention on the Rights of Persons with Disabilities
- **CSR** Corporate Social Responsibility
- **DDA** Disability Discrimination Act
- **EAA** European Accessibility Act
- **EPUB** Electronic Publication
- **ETSI** European Telecommunications Standards Institute
- **GNOME** GNU Object Model Environment
- **GUIs** Graphical User Interfaces
- **HCI** Human Computer Interface
- **HTML** Hypertext Markup Language
- **ICT** Information and Communication Technology
- **IDEA** Individuals with Disabilities Education Act
- **IOT** Internet of Things
- **ISO** International Organization for Standardization
- **KDE** Kool Desktop Environment
- **MS** Microsoft
- **NLI** Natural Language Interaction
- **OS** Operating System
- **PDF** Portable Document Format
- **SILK** Speech, images, language and knowledge

- **SST** Self-Service Terminal
- **UAAG** User Agent Accessibility Guidelines
- **UX** User experience
- **VR** Virtual Reality
- **W3C** World Wide Web Consortium
- **WAI** Web Accessibility Initiative
- **WAI-ARIA** Web Accessibility Initiative - Accessible Rich Internet Applications
- **WCAG** Web Content Accessibility Guidelines
- **WIMP** Windows, Icons, Menus and Pointers
- **XR** Mixed Reality

2. Introduction

2.1. Accessibility

The word "accessibility" can be understood as a product quality. Primarily it refers to the degree in which something is accessible by people with disabilities, but in a wider sense it also measures resistance to external or temporary handicaps, such as noisy environments or bad lighting.[1] An accessible environment or product is designed in such a way that people with disabilities can use it with the same level of ease and effectiveness as people without disabilities.[2] This includes removing physical, sensory, and cognitive barriers that prevent equal access and participation, as well as providing accommodations and assistive technologies that enable people with disabilities to interact with the environment, product, or service in a meaningful way.

In a broader sense, accessibility means that barriers and obstacles have been removed in order to enable individuals to access and fully participate in society. This includes issues such as physical barriers in the built environment, lack of transportation options, or discriminatory policies and practices.

Accessibility is one major criteria in ensuring equal rights and opportunities for people with disabilities, and it is increasingly becoming a legal and ethical requirement in many countries and industries. Therefore, the goal of accessibility is to ensure that people with disabilities can access, use, and benefit from the same products, services, and opportunities as everyone else and hence promote social inclusion and equal opportunities for all individuals, regardless of their background or circumstances.

The formal, most appropriate and universally used definition can be found in the ISO 9241.112:2017, section 3.15: “Accessibility is the extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of user needs, characteristics and capabilities to achieve identified goals in identified contexts of use.” [3]

[1] Definition of Accessibility (https://www.w3.org/People/Bos/DesignGuide/accessibility.html)
[2] W3C on Accessibility (https://www.w3.org/WAI/fundamentals/accessibility-intro/)

2.2. Roots of Accessibility

In early history, people with disabilities were often stigmatised and excluded from society, with only few accommodations made for their needs. In mediaeval Europe, some monasteries and hospitals provided care for people with disabilities, including those who were blind or deaf. These institutions were often run by religious orders and provided basic education, vocational training, and medical care. During these times, individuals with disabilities were primarily regarded through the lens of charitable acts. Still, it was not until the 20th century that accessibility became a more widespread concern. The disability rights movement of the 1960s and 70s brought attention to the barriers that people with disabilities faced in accessing education, employment, transportation, and other aspects of society.[4]

2.3. Accessibility in ICT matters

In today's digital age, ICT plays a vital role in our daily lives, from education and employment to social interaction and entertainment. Ensuring accessibility in ICT is not just a legal and ethical obligation but is a practical necessity. In the following, seven core arguments will be discussed:

- **ICT is a must for everybody everywhere:** ICT is not an option – it is a must in the information society: Everybody is supposed to use HCI/ICT (Human Computer Interface / Information and Communication Technology). In all aspects of our lives handling ICT is a prerequisite and a basic skill like using paper and pencil. When not accessible, people are excluded from using systems and services and thereby from participation in education, job, culture, politics, sports etc.
- **High impact with reasonable effort:** ICT provides a solid flexible base allowing adaptation towards diverse user needs and end devices. Accessibility has matured over the years and provides and elaborates a set of recommendations, guidelines, standards, techniques and tools to implement it. Accessibility support is integrated in many platforms and frameworks for an easy and efficient implementation – it's feasible at a very reasonable effort with high impact on software quality.
- **Huge individual benefit:** ICT provides enormous individual/personal benefits to all users by allowing them to access information, communicate, learn, work, and improve their health and wellbeing in ways that were once unimaginable.
- **Higher demand through demographic change:** Demographics show the big and growing number of users in an ageing society. And ageing is related to disabilities. They want to use ICT today and they will demand even stronger for it tomorrow. So, we need to be ready today for the user groups of tomorrow!
- **Human right – not a charity:** Society, politics and legislation react to these societal challenges and underline: Accessibility is not charity; it is a basic fundamental human right in the information society! Not respecting Accessibility is treated as discrimination. The way that Assistive Technology (AT), Accessibility and Design for All are covered

[3] Definiton of Accessibility (ISO 9241-112:2017, 3.15) (https://www.iso.org/obp/ui/#iso:std:iso:9241:-112:ed-1:v1:en)

[4] Fleischer, Doris and Zames, Freida. 2001. The Disability Rights Movement: From Charity to Confrontation. Philadelphia: Temple University Press.

by the UN-Convention on the rights of people with disabilities helps to understand the fundamental societal role designer and developer get.[5]

- **A business factor:** The demographic tendencies indicate that Accessibility increasingly is a factor for successful business. The exclusion of a good part of potential clients comes at a cost. People with acquired disabilities, particularly at age, expect to be able to use systems and services as they used to when they had no disability. In general, making technology accessible can be a smart business decision, as it allows companies to tap into a larger market and create more inclusive products and services.
- **A social-economic factor:** And last but not least accessibility is a social-economic factor supporting our social systems and services. AT/HCI/ICT and accessibility in general contribute to more independence, education and employment and therefore reduce costs and the pressure on social services.

2.4. Digital Accessibility

Digital accessibility is the product quality of digital products when they are accessible to everyone. These products include websites, mobile apps, and other online tools. Digital Accessibility ensures that all users can access the same information, regardless of the impairments they may have.[6] The goal of digital accessibility is to provide an equal access to information, services, and opportunities provided by digital technologies to people with disabilities.

Whether a visually-impaired person uses a screen reader to access a webpage or someone has a cognitive disability that requires straightforward content and navigation, digital accessibility involves a range of considerations.

Ensuring digital accessibility is not only a legal requirement in many countries but also a social responsibility to create an inclusive and equitable digital society. By making digital technologies accessible, people with disabilities can better participate in education, employment, and other aspects of society, ultimately promoting innovation in science and economic development.

2.4.1. Web Accessibility vs Digital Accessibility

Web accessibility is the principle that websites and associated technologies must be accessible to all individuals, regardless of their disabilities. According to the World Wide Web Consortium (W3C)[7], the Web is designed to work for all people, whatever their hardware, software, language, location, or ability. When the Web meets this goal, it is accessible to people with a diverse range of hearing, movement, sight, and cognitive ability."

[5] Miesenberger, K.: Advanced and Emerging Solutions: ICT and AT in Education of Low Vision and Blind Students (Keynote), in: Kouroupetroglou, G.: Enabling Access for Persons with Visual Impairment, Proceedings of the International Conference ICEAPVI, National and Kapodistrian University of Athens, Greece, 2015

[6] Definition of Digital accessibility (https://monsido.com/blog/digital-accessibility#:~:text=Digital%20accessibility%20is%20the%20process%20of%20making%20digital,information%2C%20regardless%20of%20the%20impairments%20they%20may%20have.)

[7] World Wide Web Consortium (https://www.w3.org/)

Digital accessibility goes beyond web accessibility to cover the accessibility of all digital materials, such as audio, video, electronic documents, mobile applications, kiosks, and animations.

The Web Accessibility Initiative (WAI)[8], a part of the W3C, established the Web Content Accessibility Guidelines (WCAG)[9], which is the global accessibility standard. The WCAG provides technical advice on how to create more accessible web content for people with disabilities.

The WCAG defines content as information on a web page or web application, including text, images, and sounds, as well as coding and markup that defines the structure and presentation. Additionally, the WCAG serves as the standard reference for many website accessibility laws. The WCAG has gone through several updates since it was first published in 1999.

2.5. Assistive Technology

Assistive technology refers to any device, equipment, software, or system that is specifically designed to help people with disabilities or functional limitations perform tasks that might be difficult or impossible for them to do without assistance. AT in general can range from simple tools like canes or hearing aids to more complex systems like voice recognition software or robotic prostheses.
The goal of AT is to increase the independence, productivity, and quality of life of individuals with disabilities by providing them with tools and solutions that compensate for their limitations and enable them to participate fully in their communities.
In this guide a main focus will be on technologies that assist persons with disabilities to fully participate in modern society, foremost the use of the internet, software programs and digital documents.

2.5.1. A brief history of Assistive Technology

The history of assistive technology is closely linked to the history of disability and rehabilitation. While the concept of assistive technology has been around for centuries, a modern era of assistive technology began in the mid-twentieth century with advances in electronics, engineering, and medicine with have found their way into AT.

In the 1950s, the first electronic devices were developed to aid people with hearing and vision impairments. The first hearing aids and cochlear implants were introduced, and the first Braille displays and screen readers for the blind were developed.

In the 1960s, AT primarily focused on developing devices such as hearing aids and wheelchairs. The passage of the Rehabilitation Act (1973)[10] and the Individuals with

[8] WAI (https://www.w3.org/WAI/)
[9] WCAG (https://www.w3.org/WAI/standards-guidelines/wcag/)
[10] Rehabilitation Act (1973) (https://uslaw.link/citation/us-law/public/93/112)

Disabilities Education Act (1975)[11] in the United States led to increased funding and research in assistive technology. This era saw the development of devices like communication boards and switches for people with severe physical disabilities, as well as the first wheelchair-mounted computers.

In the 1980s and 90s, the introduction of personal computers and the internet revolutionised the field of assistive technology. Text-to-speech software, screen magnification, and other software tools made computers accessible to people with visual and cognitive disabilities, while adaptive keyboards, switches, and pointing devices allowed people with physical disabilities to use computers.

In the 2000s, the focus shifted towards software-based AT solutions such as screen readers and magnifiers. The EU provided a significant boost to the development of AT by funding research and development projects. The EU's Disability Action Plan of 2003[12] and 2010[13] aimed to improve the accessibility of mainstream technology products and services for individuals with disabilities.

In 2019, the European Accessibility Act (EAA)[14] was passed, mandating that many products and services be made accessible to individuals with disabilities. This legislation sets minimum accessibility requirements for products and services, including computers, phones, banking services, and e-books.

In recent years, advances in robotics, artificial intelligence, and wearable technology have led to the development of even more advanced assistive devices, such as exoskeletons for people with paralysis, smart prosthetics that can be controlled with brain signals, and autonomous vehicles for people with mobility impairments. The UN CRPD[15] and courts in various countries have decided that when it is needed to assure secret ballots, authorities should provide voters with assistive technology.
Anyway, assistive technology continues to evolve and expand, with a wide range of devices and solutions available to help people with disabilities achieve greater independence and quality of life.

2.6. Assistive Technology in ICT

Assistive Technology in ICT has opened up new opportunities for individuals with disabilities to participate in education, employment, and social activities. In this passage some of the most important devices will be described in more detail.

[11] Individuals with Disabilities Education Act (1975) (https://sites.ed.gov/idea/IDEA-History)
[12] EU's Disability Action Plan of 2003 (https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2003:0650:FIN:EN:PDF)
[13] EU's Disability Action Plan of 2010 (https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2010:1324:FIN:EN:PDF)
[14] European Accessibility Act (https://eur-lex.europa.eu/EN/legal-content/summary/accessibility-of-products-and-services.html)
[15] UN CRPD (https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/convention-on-the-rights-of-persons-with-disabilities-2.html)

1. **Screen reader:** A screen reader is a type of assistive technology that reads aloud the content displayed on a computer screen or mobile device to individuals who are visually impaired or blind. It converts the visual information into speech or Braille output that can be easily understood by the user.
2. **Braille display:** A Braille display is a type of assistive technology that is used by individuals who are visually impaired or blind. It is a device that consists of a series of pins that rise and fall to form Braille characters. The Braille display is often used in conjunction with a screen reader to provide a more comprehensive experience for the user.
3. **High contrast settings:** High contrast settings are accessibility features that are designed to help individuals with visual impairments or colour blindness. This feature enhances the contrast between the background and foreground elements, making it easier for users to distinguish between different visual elements on a screen.
4. **Large font:** Large font is an accessibility feature that allows users to increase the size of text on a computer screen or mobile device. This feature is particularly useful for individuals with low vision who may have difficulty reading small fonts. Users can adjust the font size to a level that is comfortable for them, which can help reduce eye strain and improve readability.
5. **Screen magnification:** Screen magnification is a type of assistive technology that enlarges the content displayed on a computer screen or mobile device. This feature is used by individuals with low vision or visual impairments, as it allows them to magnify the screen to a level that is comfortable for them. The user can adjust the magnification level and pan across the screen to focus on specific areas.
6. **Keyboard-mouse:** This is a feature that allows users to utilise the keyboard as an alternative to the mouse. It is especially useful for people with mobility impairments who may not be able to use the mouse. With a keyboard-mouse, users can use the arrow keys to move the cursor, the spacebar to click, and other keyboard shortcuts to perform mouse-related tasks.
7. **Special joysticks and mouse alternatives:** There's a variety of alternative joysticks that address different types of special needs. These joysticks (naming some features exemplary) can be controlled with one hand only, have oversized buttons or buttons instead of a stick, several sip/puff pressor sensors along with a lip position sensor, and joysticks that aren't physical controllers but software solutions which emulate a joystick using customisable voice commands. Mouse alternatives like the Integra Mouse[16] or the Jouse+[17] are specialised mouth-controlled input devices that are designed to provide an alternative to the standard mouse. The slightest movement of lips will control the mouthpiece and move the mouse across the computer screen. By simply sipping and puffing, one can trigger mouse clicks as with any standard mouse.
8. **Trackball:** A trackball is an input device that is similar to a mouse but is stationary. The user moves the cursor by rolling a ball with their fingers, rather than moving the entire device. Trackballs are often used by people with limited mobility or those who prefer a stationary device.

[16] Integra Mouse (https://www.integramouse.com/)
[17] Jouse+ (https://www.compusult.at/jouse)

9. **Eye-tracking device:** this technology[18] can be used by persons who have significant physical disabilities to be more independent. The way it works is that a camera tracks the person's eye movements, which then moves the mouse on a computer screen. The user selects items either by holding their gaze for a certain time, referred to as 'dwell', by blinking, or by clicking an external button.
10. **Brain Computer Interfaces:** A brain-computer interface (BCI) is a technology that enables people to control computers or other devices using only their brainwaves. This technology can be used by people with severe physical disabilities, such as those with spinal cord injuries, to control their computers and other devices. BCI systems work by translating brain activity into computer commands, allowing users to perform a range of tasks without the need for traditional input devices like a mouse or keyboard.

2.6.1. Human-Computer Interface

A Human-Computer Interface (HCI) refers to the point of interaction between a human user and a computer system. It is the means by which a user interacts with a computer or other digital devices, and includes all of the hardware and software components that allow for this interaction.
The goal of HCI is to create a seamless and intuitive experience for users, allowing them to interact with digital devices in a way that is natural, easy to understand, and efficient. This can involve the design of interfaces such as graphical user interfaces (GUIs), voice recognition systems, touchscreens, and other input/output devices.
HCI encompasses many different areas, including usability, accessibility, and user experience design. Usability refers to the ease of use and efficiency of a system, while accessibility involves making systems accessible to people with disabilities or impairments. User experience design is concerned with the overall experience of a user, including factors such as ease of use, engagement, and satisfaction.
Effective HCI design requires an understanding of user needs, preferences, and abilities, as well as an understanding of the technical capabilities and limitations of the system. By designing interfaces that are intuitive, user-friendly, and accessible, HCI can help to improve the efficiency and effectiveness of human-computer interactions, and enhance the overall user experience.

2.6.2. Core Qualities of Human Computer Interfaces

The core qualities of human-computer interfaces (HCI) are typically considered to be usability, usefulness, and user experience.

- **Usability:** The usability of an interface refers to its ease of use and efficiency. A usable interface is one that is intuitive and easy to learn, allowing users to quickly and efficiently perform tasks. Usability is often evaluated through user testing and feedback.
- **Usefulness:** The usefulness of an interface refers to its ability to support users in achieving their goals. A useful interface provides features and functionality that are

[18] Eyegaze (https://eyegaze.com/)

relevant and valuable to users, and helps them to accomplish their tasks effectively. Usefulness is often evaluated through user research and feedback.

- **User experience:** The user experience (UX) of an interface encompasses a user's emotions, attitudes, and perceptions about their interaction with the system. A positive user experience involves factors such as ease of use, engagement, satisfaction, and enjoyment. UX is often evaluated through user feedback and surveys.

In addition to these core three qualities of HCI there are further aspects that can be considered to play a critical role:

- **Accessibility:** Accessibility is acknowledged to be a crucial aspect of HCI. At this point it is worth mentioning that usability and accessibility are often mistaken, but as pointed out are not the same. An accessible interface is one that can be used by individuals with disabilities or impairments, allowing them to access and benefit from the same functionality as other users.

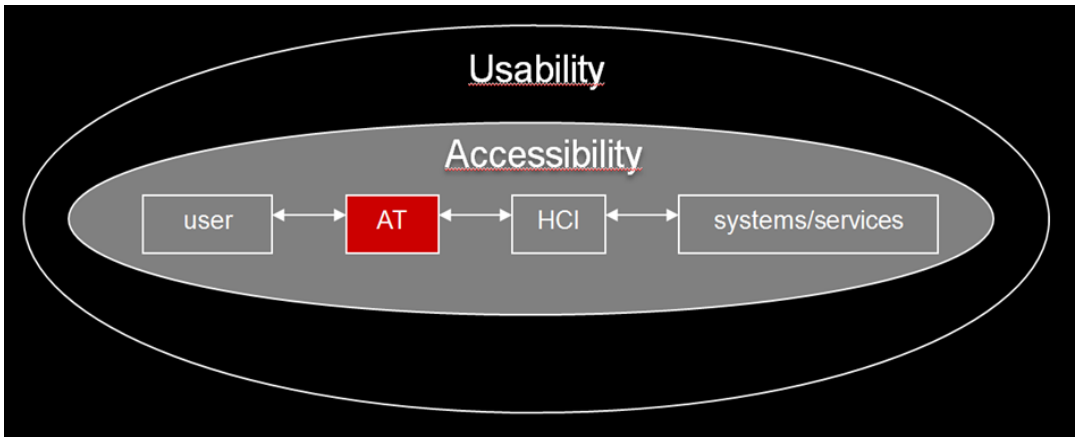

Fig.1 The ICT/HCI/AT interplay[19]

This graphic outlines that people with disabilities use Assistive Technologies (AT) to interact with the HCI which provides standardised interaction with systems and services. In engineering, it is common to provide interfaces for interaction, input and output. The same holds true for the accessibility domain. The accessibility domain includes additional techniques, which allow implementing an increased flexibility for people with disabilities.

- **Flexibility:** This quality addresses the adequate choice in regards to the multi-media display of information (e.g. visual, audio or haptic) as well as a multi-modality of interaction (e.g. mouse, keyboard, switches, speech, Brain-Computer-Interfaces).
- **Adaptability:** The aspect of adaptability in HCI hints at easy customisation for one's own needs including the use of (preconfigured) profiles for basic target groups.
- **Universality:** The universal and standardised nature of ICT tools makes them an ideal means for promoting inclusivity. By ensuring that (the limited number of) elements and actions in HCI are designed "accessible" and are integrated in assistive technologies, the way for greater participation and inclusion across all domains of

[19] Miesenberger, K.: Best Practice in Design for All, in: Stephanidis (ed.): The Universal Access Handbook, CRC Press, Boca Raton 2009

society is paved - foremost where ICT applications are employed. This is particularly significant in the contemporary era, where digitalisation is omnipresent.

2.7. The Interface

We could analyse many technological revolutions (e.g. radio, TV, telephone, car) and would identify similar “excluding” tendencies for people with disabilities. Information and Communication Technology (ICT) is the first and ultimate technology, which is fundamentally different in this aspect. It provides the broadest level of flexibility and adaptability ever available which merits our attention to understand the fundamental role of ICT for inclusion and participation of people with disabilities.
One of the key achievements of the ICT revolution is the separation of the interface from the actual functioning of a tool. The interface has become an independent entity using a limited number of well-defined and universally applicable elements.

2.7.1. Desktop example

A limited number of elements (WIMP: Windows, Icons, Menus and Pointers expanded by SILK: speech, images, language and knowledge) and a limited number of actions (e.g. Create, Delete, Point & Click, Drag & Drop) can create unlimited applications.
These elements and actions can be applied to any software-based ICT tool. And as ICT is used in almost any domain today, the standardised Human-Computer Interface (HCI) has become a universally applied and stable instance to which all applications converge.

3. Document Accessibility

According to the Web Content Accessibility Guidelines (WCAG)[20] an accessible document is a document that can be read and accessed by a wide range of users, regardless of their physical or cognitive abilities. This means that it should be easy to read with a screen reader, viewed in large print or with changes to contrast, and browsed in a structured and understandable manner, such as from chapter to chapter or from paragraph text to footnotes. Additionally, an accessible document should be robust, meaning that it should not lose any information when it is used to create other formats.

To make a document accessible in practice, it is necessary to create it in a structured and navigable manner, using inbuilt functionality such as tables, lists, and notes rather than customised methods. It is also important to provide text descriptions for any graphic content, such as pictures, flow charts, and maps, to ensure that visually impaired users can understand the information conveyed by these elements. Finally, an adaptable format that is marked-up semantically should be used to ensure that readers can adjust the visual presentation of the document to meet their needs. This involves using appropriate built-in styles to reflect the meaning of different text elements and visual presentation, such as colour and alignment.

[20] WCAG (https://www.w3.org/WAI/standards-guidelines/wcag/)

3.1. A brief background to Document Accessibility

The history of document accessibility can be traced back to the early 20th century when Braille[21] was first introduced as a way to make written materials accessible to people with visual impairments. However, it wasn't until the introduction of digital technology that document accessibility truly began to advance.

In recent years, there has been a growing recognition of the importance of document accessibility, with many organisations adopting policies and guidelines to ensure that their documents are accessible to all. This includes efforts to make electronic documents, such as PDFs and Word documents, accessible by adding alt text, providing proper document structure, and using accessible fonts and colours.

3.2. Guidelines

3.2.1. Born Accessible Publishing

Born accessible publishing refers to creating content that meets accessibility guidelines from the outset. With the EU requiring digital publications to be accessible by 2025[22] , it's crucial to efficiently incorporate accessibility into your publication process. Waiting until the end of the process to make content accessible can be burdensome and potentially result in a subpar user experience if content needs to be altered for accessibility.
To avoid these issues, it's recommended to implement accessibility checks throughout the process. This allows you to avoid relying on external parties, like transcription organisations, to make accessible versions of your publications, which can cause delays and inconvenience for users. By making accessibility a priority from the beginning, you can ensure an inclusive and seamless user experience for all.

3.3. Formats for digital publishing

To publish digital materials[23], there are various file formats to choose from. PDF[24] is a reliable format to replicate a print copy, but it has limitations in terms of altering the layout and can cause accessibility issues on smaller screens or for people with low vision.

EPUB 3[25] offers a fixed layout option, but it also presents accessibility challenges. However, EPUB 3 has more options for navigation and discoverability than PDF. Websites offer more flexibility for interactive and accessible content, but it can be difficult to distribute a confined

[21] What is Braille (AFB) (https://www.afb.org/blindness-and-low-vision/braille/what-braille)
[22] European Accessibility Act: Q&A (https://ec.europa.eu/social/main.jsp?catId=1202&intPageId=5581&langId=en)
[23] Learning material: (https://www.inclusivepublishinginpractice.org)
[24] PDF standard: ISO 32000 (https://www.iso.org/standard/51502.html)
[25] EPUB 3 (W3C) (https://www.w3.org/publishing/epub3/epub-overview.html)

publication as a website. The EPUB format offers a solution as it uses open and accessible web standards and can be distributed as a single publication.

EPUB 2 is still a popular publication format for leisure reading books, but it may not support more complex content like MathML[26], SVG[27] images or fixed layouts. To ensure your publications meet accessibility guidelines and remain futureproof, it's recommended to use EPUB 3.

Microsoft Word is one of the most widely used applications for creating and editing documents. However, Microsoft Word is not the only option available for creating and editing documents. There are other applications that are compatible with Microsoft Word[28] , such as LibreOffice[29], which offers similar functionality and is free to use.
While Word files are sometimes used for publishing purposes, it's important to note that their primary purpose is to facilitate document creation and collaboration. Word files are not ideal for publishing due to their limited layout and design options. However, the creation of accessible Word files is important because they can be easily converted to PDF files, which are commonly used for publishing.

3.3.1. EPUB

EPUB is an e-book file format developed by the International Digital Publishing Forum (IDPF)[30] in 2007 as version 2.0, succeeding the Open eBook standard introduced in 1999. This format allows stakeholders in the publishing business to create documents that can be distributed to different reading systems such as e-readers and apps for PC and mobile devices. EPUB uses HTML, allowing publishers to follow the Web Content Accessibility Guidelines (WCAG) and make content accessible from the start. The DAISY Consortium[31] has contributed to the design of the EPUB format to ensure that it enables the creation of born accessible publications.

EPUB version 3, introduced in 2011, added new features such as support for HTML5[32] elements, MathML, and SVG. With support for these modern web standards, an EPUB file can also be considered as a packaged website. In 2017, the IDPF merged with the World Wide Web Consortium (W3C) to align publisher technologies with the web. This highlights the thin line between EPUB and web content. Publishers need not have any additional expertise to create an accessible EPUB compared to creating accessible web content.

[26] MathML (W3C) (https://www.w3.org/Math/)
[27] SVG (https://www.w3.org/Graphics/SVG/)
[28] Microsoft Word (https://www.microsoft.com/microsoft-365/word)
[29] LibreOffice (https://www.libreoffice.org/)
[30] International Digital Publishing Forum (IDPF) (https://idpf.org/)
[31] DAISY Consortium (https://daisy.org/)
[32] HTML Standard (https://html.spec.whatwg.org/multipage/)

3.3.2. EPUB Accessibility

EPUB[33] heavily relies on open web standards, which allows publishers to utilise existing guidelines for accessible web content. This includes semantic HTML5 elements, responsive layout, ARIA roles, and text alternatives for images. EPUB also offers additional accessibility features such as navigational elements that enable users to browse the publication based on headings, page numbers, and landmarks. Another feature is media overlays, which allows for synchronised text and audio, making it beneficial for users with dyslexia or those who have difficulty focusing on text. Additionally, EPUB includes accessibility metadata that contains basic information about the publication, including available accessibility features, which is useful for both the user and the publisher to ensure discoverability of information.[34]

3.4. Office documents

It's crucial to create accessible office documents since they can be readily transformed into PDF files, which are widely employed for publishing. Office documents include word processing (Microsoft Word[35], LibreOffice Writer[36]...), spreadsheets (Microsoft Excel[37], LibreOffice Calc[38]...) and presentations (Microsoft PowerPoint[39], LibreOffice Impress[40],...). Creating accessible office documents files involves considering factors such as the use of appropriate heading styles, alt text for images, and accessible tables. These elements help to ensure that the document is accessible to all users, including those with disabilities. The accessibility of the resulting PDF files will depend on the accessibility of the original office file, which underscores the importance of creating accessible office files from the outset. The following chapter describes the creation of an accessible office document created by a word processor, such as Microsoft Word. Many of these techniques can be transferred to other common office programmes like spreadsheets or presentations, which usually consist of similar elements.

3.4.1. Creation of an accessible document of a word processing application (e.g. Microsoft Word)

To ensure that a Word Document meets accessibility requirements[41], it can be helpful to follow a five-step process, which includes the following:

[33] Accessibility requirements for EPUB publication: (https://www.w3.org/Submission/epub-a11y/)
[34] Requirements for verifying EPUB publication: (https://www.iso.org/standard/76860.html)
[35] LibreOffice Writer (https://www.libreoffice.org/discover/writer/)
[36] Microsoft Word (https://www.microsoft.com/microsoft-365/word)
[37] Microsoft Excel (https://www.microsoft.com/microsoft-365/excel)
[38] LibreOffice Calc (https://www.libreoffice.org/discover/calc/)
[39] Microsoft Powerpoint (https://www.microsoft.com/microsoft-365/powerpoint)
[40] LibreOffice Impress (https://www.libreoffice.org/discover/impress/)
[41] Best practices: (https://support.microsoft.com/en-us/office/make-your-word-documents-accessible-to-people-with-disabilities-d9bf3683-87ac-47ea-b91a-78dcacb3c66d)

- **Image processing:** Providing text descriptions for graphic content, such as pictures and charts, to ensure that visually impaired users have access to important information.
- **Document and text structuration:** Creating a structured and navigable document using inbuilt functionality for elements such as headings, titles, lists, and notes rather than customised methods.
- **Tables:** Ensuring that tables are created in a way that represents tabular data, and that the content reads logically from left to right and row by row when pasted into a plain text block note. Table headers for columns and / or rows need to be marked up as well.
- **Colour management:** Checking that colour contrast is sufficient and that no information is conveyed through colour alone.
- **Definition of document metadata:** Including title and author details in the Properties menu to provide additional context for readers.

By following these steps, your document will be more accessible, and it can be exported to other formats without losing any information.

3.4.2. Automatic Accessibility Evaluation

The Word Accessibility Checker[42] is a tool that examines Word files for potential accessibility issues based on predetermined rules. The Accessibility Checker categorises issues into three types: Errors, Warnings, and Tips, depending on their severity. Errors are issues that prevent users with disabilities from accessing the document, such as images with no alt text. Warnings indicate issues that make it challenging for people with disabilities to access the document, such as links with non-descriptive text. Tips highlight areas that could be better organised or presented, such as jumping from a first-level heading to a third-level heading.

However, while the Accessibility Checker can detect some issues, such as contrast problems with text and missing table headings, most flagged issues require additional manual inspection. Therefore, it's important to review the document thoroughly and make any necessary changes to ensure accessibility for all users.

3.4.3. Manual Accessibility Evaluation

Testing the document with a screen reader is one of the best ways to run manual tests and identify possible accessibility issues. The following checklist can be used to run through the document. Still, the manual accessibility evaluation process can’t be covered by the use of a screen reader alone. The following checklist can be used to go through the document and ensure that certain elements meet accessibility guidelines and best practices. Here are the checkpoints to follow:

- **Images:** Check that descriptions of all images, charts, and graphics that convey information are meaningful and appropriate.

[42] Introduction to Word Accessibility Checker (https://support.microsoft.com/en-us/office/improve-accessibility-with-the-accessibility-checker-a16f6de0-2f39-4a2b-8bd8-5ad801426c7f)

- **Headings:** Review the heading hierarchy in the navigation panel and ensure that all headings are correctly styled and included in the panel at the appropriate level.
- **Bulleted and numbered lists:** Check that lists in the document are correctly structured and that bullet points or numbers can't be selected individually.
- **Footnotes:**[43] Ensure that footnotes have been added using the correct functionality in the References tab and that they are accessible.
- **Links:** Check that any link text is meaningful and not just "click here."
- **Document layout:** Verify that font size is no smaller than 12, sans-serif fonts are used, italics and underlining are avoided, text is not justified, and spacing is appropriate.
- **Tables:** Check that only tabular data is represented in tables, and that table content reads from left to right row by row in a logical order.
- **Use of colour:** Check that colour contrast is sufficient and that no information is conveyed through colour alone.
- **Reading order:** Test that columns, sidebars, and text boxes are read out in a logical order using a screen reader.
- **Metadata:** Check that the metadata tab includes the title of the document and author details in the Properties menu.

3.5. PDF

PDF is commonly used for digital document distribution, but EPUB 3 has many accessibility advantages over PDF (see EPUB module). However, if PDF is the only option available, it is possible to create an accessible publication in this format. Programs like Microsoft Word and Adobe InDesign[44] provide an option to export documents as PDF, while Adobe Distiller[45] and Adobe Acrobat Pro[46] can refine PDF files exported from those programs.

Creating an accessible PDF[47] typically involves two stages.

1. An already accessible document is exported in an intermediary format or directly as a PDF using a document creation tool.
2. The output PDF is checked and repaired for any accessibility issues using Adobe Acrobat Pro.

3.5.1. Export of PDFs

To create accessible PDFs, it is important to follow general accessibility guidelines that apply to all digital formats, such as considering colour, layout, navigation, structure, and images and providing text alternatives. Once the source document has been verified for accessibility, it can be exported to PDF while ensuring that the exporting tool is set to create

[43] How to create accessible footnotes in Word: (https://support.microsoft.com/en-us/office/use-a-screen-reader-to-read-and-edit-footnotes-and-endnotes-in-word-71427011-d8ad-4f5a-8ddc-f3b8718c3446)
[44] Adobe InDesign (https://www.adobe.com/products/indesign.html)
[45] Adobe Distiller (https://helpx.adobe.com/acrobat/using/creating-pdfs-acrobat-distiller.html)
[46] Adobe Acrobat Pro (https://www.adobe.com/acrobat/acrobat-pro.html)
[47] PDF Accessibility Guide (https://www.adobe.com/accessibility/pdf/pdf-accessibility-overview.html)

accessible PDF using the PDF/UA[48] standard. After exporting, an accessibility check should be performed on the resulting PDF document to ensure that it meets accessibility requirements. While most accessibility features will be preserved if correctly implemented in the source document, the export process can introduce some accessibility issues, making an accessibility check after exporting crucial.

3.5.2. Accessibility Remediation

The same accessibility remediation process applies to PDFs exported from accessible formats and those from other workflows. To make PDF files accessible to all users, the files need to go through an accessibility remediation process. This process involves using software tools, such as Adobe Acrobat Pro, to check and fix issues with the file's accessibility.

One important aspect of accessibility remediation is providing alternative text for non-text content, such as images, so that users with visual impairments can still understand the content. It's also important to ensure that the document has a proper reading order and sufficient colour contrast for readability.

It's important to note that PDFs are often chosen for their complex layout and graphics, making accessibility remediation a time-consuming and challenging task. To make the PDF accessible, it's necessary to assess its accessibility and solve any issues found, such as making sure the content is tagged correctly and has a logical structure.

3.5.3. PDF/UA

PDF/UA (Universal Accessibility)49 is a substandard of the PDF standard (ISO 32000-1)50 for accessible PDF documents. PDF/UA defines how to apply the PDF standard so that a PDF document can meet accessibility requirements. PDF/UA is not a separate file-format but simply a way to use the familiar PDF format invented by Adobe Systems and now standardised as ISO 32000.

The requirements of PDF/UA are based on the requirements of the Web Content Accessibility Guidelines (WCAG). The guidelines describe the nature of accessible web content, make numerous recommendations and formulate testable, non-technology-specific success criteria. On the other hand, PDF/UA defines the technical requirements for accessible PDF documents based on the PDF standard. These requirements provide a quality standard for accessible PDF documents and also provide guidance for the development of compliant display or processing programs as well as compliant assistive technologies. The requirements for a PDF/UA-compliant, accessible document consist of the

[48] PDF/UA (https://pdfua.foundation/en/)
[49] PDF/UA (https://pdfua.foundation/en/)
[50] ISO 32000-1 (https://www.iso.org/standard/51502.html)

technical and content-related properties of the PDF file.[51] A central aspect here is the marking of the relevant content with PDF tags. The Matterhorn Protocol[52] is available to users for implementation. The Matterhorn Protocol consists of 31 test points with a total of 136 fault conditions (criteria for conformity).

4. Web Accessibility

4.1. History and legal background of Web Accessibility

Web accessibility refers to the practice of designing and developing websites and web applications that can be accessed and used by people with disabilities. The history of web accessibility dates back to the early days of the World Wide Web, when the first websites were being created. Legal aspects of web accessibility refer to the laws, regulations, and guidelines that mandate website owners and operators to ensure that their websites are accessible to people with disabilities. Some major legal milestones of web accessibility in the USA and Europe have been:

In 1990, the Disabilities Act (ADA)[53] was established: The ADA is a federal law in the United States that prohibits discrimination against individuals with disabilities. Title III of the ADA requires businesses and organisations that are open to the public to make their websites accessible to people with disabilities.

In 1994, the World Wide Web Consortium (W3C) was established to develop standards for the web. In 1995, the Disability Discrimination Act (DDA)[54] was established: The DDA is a UK law that prohibits discrimination against individuals with disabilities. It requires service providers to make reasonable adjustments to ensure that their services, including websites, are accessible to people with disabilities.

In 1998, the US government passed Section 508[55] of the Rehabilitation Act, which requires federal agencies to make their electronic and information technology accessible to people with disabilities. This was a significant milestone in the history of web accessibility, as it set a precedent for accessibility requirements in the private sector as well.

In 1999, the Web Content Accessibility Guidelines (WCAG 1.0) were first published: The WCAG is a set of international guidelines developed by the World Wide Web Consortium[56] (W3C) that provide technical recommendations on how to make web content more accessible to people with disabilities. The WCAG is widely used by businesses and

[51] PDF Accessibility Checker (German language): (https://pdfua.foundation/de/pac-2021-der-kostenlose-pdf-accessibility-checker/)
[52] The Matterhorn Protocol 1.1: (https://pdfa.org/resource/the-matterhorn-protocol/)
[53] ADA: (https://www.ada.gov/)
[54] DDA: (https://www.legislation.gov.uk/ukpga/1995/50/contents)
[55] Section 508: (https://www.section508.gov/)
[56] World Wide Web Consortium (W3C): (https://www.w3.org/)

organisations as a standard for web accessibility. Later versions have been the WCAG 2.0 (2008) and the WCAG 2.1 (2018).

In 2008, the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD)[57] was adopted, which recognized access to information and communications technologies as a human right. This further emphasised the importance of web accessibility and led to the development of global accessibility standards.

The European Web Accessibility Directive[58] is a legislative act adopted by the European Union in 2016, which aims to ensure that websites and mobile applications of public sector bodies are accessible to everyone, including people with disabilities. The Directive sets out specific requirements for accessibility, based on the harmonised standard EN 301 549[59] which is in line with Web Content Accessibility Guidelines (WCAG) 2.1[60].

In recent years, there has been a growing awareness of the importance of web accessibility, both from a legal and ethical standpoint. Many countries have enacted accessibility laws, and there has been a push for more inclusive design practices in the tech industry. Despite these efforts, web accessibility remains a challenge. Many websites and web applications still lack basic accessibility features, making it difficult or impossible for people with disabilities to access them.

4.2. Target groups of Web Accessibility

Web accessibility affects a wide range of people with disabilities, including:

- **Blind people:** People who are blind use screen readers or braille displays to access web content. Therefore, web content should be designed to be compatible with these assistive technologies.
- **Visually impaired people:** People with visual impairments may have difficulty with contrast, colour, and font size. Web content should be designed to be legible and easy to read, and alternative text should be provided for images.
- **Deaf/hard of hearing people:** Deaf or hard of hearing people may rely on captions, transcripts, and sign language interpretation to access audio and video content on the web.
- **People with motor disabilities:** People with motor disabilities may have difficulty using a mouse or keyboard. Web content should be designed to be accessible with alternative input devices such as voice recognition software, head pointers, or eye tracking devices.
- **People with cognitive disabilities:** People with cognitive disabilities may have difficulty understanding complex information or navigating complicated web

[57] UNCRPD (EC): (https://ec.europa.eu/social/main.jsp?langId=en&catId=1138)
[58] European Web Accessibility Directive: (https://web-directive.eu/)
[59] EN 301 549:
(https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf)
[60] WCAG Quick Refs: (https://www.w3.org/WAI/WCAG21/quickref)

interfaces. Web content should be designed to be simple and easy to understand, and should provide clear instructions and feedback.

- **Older people:** Older people may have age-related impairments which often result in a combination of two or more of the aforementioned types of disabilities.
- **Everyone:** Depending on the context and situation everyone can temporarily face accessibility related issues. Mobile phone users rely on responsive web content. The usage of devices outdoors in sunlight requires high contrast ratios to keep the text readable. Users of touch devices require bigger click targets (buttons etc), and so on.

4.3. Further benefits from Web Accessibility

- **Search engines:** Search engines rely on web content to provide relevant search results to users. When web content is accessible, search engines can more easily analyse and index it, leading to better search results for all users. Also, websites, which allow easy access to web crawlers of search engines, usually get higher ranked in the search results.
- **Public Relations (PR) and Corporate Social Responsibility (CSR):** Accessibility can enhance a company's image and reputation as an inclusive and socially responsible organisation. It can also help to attract and retain customers who value accessibility.
- **Legal compliance:** Many countries and regions have laws and regulations in place that require websites and digital content to be accessible to people with disabilities. Ensuring web accessibility can help organisations comply with these legal requirements and avoid potential lawsuits or penalties.

4.4. Standards and International Guidelines

4.4.1. WCAG

The WCAG is a set of guidelines that provide recommendations for making web content more accessible to people with disabilities, and are widely regarded as the international standard for web accessibility. The WCAG was developed by the W3C, which is an international standards organisation that is responsible for developing standards for the World Wide Web. The W3C has played a central role in the development of web accessibility standards, and the WCAG is widely regarded as the international standard for web accessibility.

4.4.2. EN 301 549

EN 301 549[61] is a European standard that was developed by the European Telecommunications Standards Institute (ETSI) to provide technical requirements for accessibility of ICT products and services. The standard is based on the WCAG 2.1, and covers a wide range of ICT products and services, including websites, software applications, and electronic documents. The standard includes requirements for accessibility features such as keyboard navigation, text alternatives for images, and the use of accessible colours.

4.4.3. BITV

BITV[62] stands for "Barrierefreie Informationstechnik-Verordnung", which translates to "Accessible Information Technology Regulation" in English. The BITV guidelines are based on the EN 301 549 and are a set of accessibility guidelines for web-based services and products in Germany, and it is closely related to the European Web Accessibility Directive, as it was developed to implement the Directive's accessibility requirements in Germany. BITV interprets WCAG more specifically in some places and offers methods and test procedures to test individual criteria, which can help developers to implement accessible web content.

4.4.4. ATAG

ATAG[63] stands for "Authoring Tool Accessibility Guidelines", which is a set of guidelines developed by the World Wide Web Consortium (W3C) to provide guidance on how to make authoring tools more accessible to people with disabilities.

Authoring tools are software applications that are used to create web content, such as content management systems, website builders, and text editors. These tools can create barriers to accessibility if they are not designed with accessibility in mind. For example, a content management system that does not provide accessible templates or the ability to add alternative text to images can create accessibility barriers for users with disabilities.

ATAG provides a set of guidelines for developers of authoring tools to ensure that their tools are accessible to all users, including those with disabilities. The guidelines cover a wide range of issues, including the accessibility of the user interface, the availability of accessibility features, and the ability to create accessible content. The guidelines work in conjunction with other accessibility standards, such as the Web Content Accessibility Guidelines (WCAG).

[61] EN 301 549 (https://www.etsi.org/deliver/etsi_en/301500_301599/301549/03.02.01_60/en_301549v030201p.pdf)
[62] BITV (https://www.bitvtest.eu/home.html)
[63] ATAG (https://www.w3.org/WAI/standards-guidelines/atag/)

4.4.5. UAAG

UAAG[64] stands for "User Agent Accessibility Guidelines" and guides developers in designing user agents that make the web more accessible to people with disabilities. User agents are software applications that enable users to access and interact with web content, such as web browsers, media players, and assistive technologies. These tools can create barriers to accessibility if they are not designed with accessibility in mind. For example, a web browser that does not provide keyboard shortcuts or the ability to resize text can create accessibility barriers for users with disabilities.

UAAG provides a set of guidelines for developers of user agents to ensure that their tools are accessible to all users, including those with disabilities. UAAG guidelines, again, work in conjunction with other accessibility standards, most notably the Web Content Accessibility Guidelines (WCAG).

4.4.6. WAI-ARIA

WAI-ARIA[65] stands for "Web Accessibility Initiative - Accessible Rich Internet Applications". It is a set of technical specifications developed by the World Wide Web Consortium (W3C) to provide a way to make dynamic content and web applications more accessible to people with disabilities.

Traditionally, web content was created using HTML, which provides a basic structure and semantics for content on the web. However, as web technologies have evolved, web applications have become more complex, with dynamic content and interactivity. This has created challenges for accessibility, as the traditional HTML semantics are not always sufficient to convey the information and functionality of these applications to users with disabilities.

WAI-ARIA provides a way to supplement the traditional HTML semantics with additional accessibility information, such as the role, state, and properties of user interface components. By adding this information, developers can create more accessible web applications that are easier for people with disabilities to use.

4.5. WCAG 2.1

WCAG 2.1[66] is based on four principles, each of which has its own set of guidelines. These principles are:

- **Perceptible:** Information and user interface components must be presentable to users in ways they can perceive.
- **Operable:** User interface components and navigation must be operable.

[64] UAAG (https://www.w3.org/WAI/standards-guidelines/uaag/)

[66] WAI-ARIA (https://www.w3.org/WAI/standards-guidelines/aria/)
[66] WCAG 2.1: (https://www.w3.org/TR/WCAG21/)

- **Understandable:** Information and the operation of the user interface must be understandable.
- **Robust:** Content must be robust enough that it can be interpreted reliably by a wide variety of user agents, including assistive technologies.

Each principle has a set of guidelines that are further divided into success criteria. The success criteria are grouped into three levels: A, AA, and AAA. Each level builds upon the previous one. For example, to meet level AA, all level A criteria must be satisfied, and to meet level AAA, all level AA and A criteria must be satisfied.

Examples of web accessibility aspects covered in each principle are:

4.5.1. WCAG - Perceivable

This means that users must be able to perceive the information being presented (it can't be invisible to all of their senses).

- Provide text alternatives for all non-text content so that it can be changed to other forms needed by the user, such as large print, Braille, symbols, or simpler language.
- Provide alternatives for time-based media.
- Create content that can be presented in different ways (for example, with simpler layout) without losing information or structure.
- Make it easier for users to see and hear content, including separation between foreground and background.

4.5.2. WCAG - Operable

This means that users must be able to operate the interface (the interface cannot require interaction that a user cannot perform).

- Make sure that all functionality is available via the keyboard.
- Give users enough time to read and use content.
- Do not design content in ways that are known to cause seizures.
- Provide means to help users navigate, find content, and determine where they are.

4.5.3. WCAG - Understandable

This means that users must be able to understand the information as well as the operation of the user interface (the content or operation cannot be beyond their understanding)

- Make text content readable and understandable.
- Make sure websites look and function predictably.
- Help users avoid and correct errors.

4.5.4. WCAG - Robust

This means that users must be able to access the content as technologies advance (as technologies and user agents evolve, the content should remain accessible).

- Maximise compatibility with current and future user agents, including assistive technologies.

4.6. Web Accessibility Testing

Web accessibility testing is an essential part of ensuring that websites and digital content are accessible to all users, including those with disabilities. There are two main approaches to web accessibility testing: manual/assisted testing and fully automated testing.

4.6.1. Manual/Assisted Accessibility Testing vs. fully Automated Accessibility Testing

Manual/assisted accessibility testing involves using a combination of manual assessment techniques also involving assistive technologies, such as screen readers and magnifiers, and tools that support the evaluator in checking a website's accessibility. This approach requires human testers to review aspects of elements of a website manually and the outcome of testing tools.

Fully automated accessibility testing, on the other hand, uses software tools to automatically test websites for accessibility issues. This approach is faster and less resource-intensive than manual testing, but it is NOT accurate. While automated testing tools can help to show trends, it is no adequate or sufficient method for web accessibility testing.

HTML, CSS and JS content on usual websites are extremely complex, and it is not possible for automated testing tools to accurately determine how a page looks before it is rendered by a browser. Additionally, alternative text and other accessibility features cannot be adequately evaluated for their meaningfulness within a certain context, making manual testing essential in many cases. For example: the same image can have a totally different meaning in a different context.

In summary, testing tools can simplify evaluation steps or show a trend, but they should not be relied upon exclusively for accessibility testing. Manual/assisted testing is still necessary to ensure that a website is fully accessible to all users, including those with disabilities.

4.6.2. Web Accessibility Testing Tools

Web accessibility testing is a critical step in ensuring that websites and digital content are accessible to people with disabilities. There are several tools available that can help with web accessibility testing, including:

- **Screen reader:** A screen reader is a software program that reads the content of a website out loud to the user. NVDA (NonVisual Desktop Access) is a popular and

free screen reader that can be used to test website accessibility for people with visual impairments. A popular commercial alternative is JAWS for Windows. But most operating systems also have (less popular) screen readers built in, including mobile ones (Android, iOS)

- **Web Developer Plugin:** The "Web Developer Plugin" is a popular plugin that can be installed on Firefox and Chrome. This plugin provides a range of accessibility testing tools, such as highlighting images without alt tags, listing headings and landmarks, and displaying colour contrast ratios.
- **Website Checker:** WAVE (Web Accessibility Evaluation Tool) is a free online tool that can scan websites and provide feedback on accessibility issues. WAVE displays the accessibility errors and warnings on the webpage and provides suggestions.
- **HTML Validator:** The W3C HTML Validator is a free online tool that checks the HTML code of a website for syntax errors. Required for WCAG criterion 4.1.1
- **Code Analysis:** Integrated code analysis tools are available in Firefox and Chrome. The Firefox Inspector and Chrome DevTools can be used to identify accessibility issues in the HTML and CSS code of a website.

The screen reader, W3C HTML Validator, and code analysis tools are essential for web accessibility testing. Without them, a website cannot be comprehensively tested for accessibility. Although the web developer plugin and WAVE can provide support and expedite the process, it is important to note that more automated features cannot be fully relied upon and require manual review, such as contrast checks and missing alt-texts. Above you can find different free web resources where info can be completed:

- Web Developer Plugin (Firefox): (https://addons.mozilla.org/de/firefox/addon/web-developer/)
- Web Developer Plugin (Chrome): (https://chrome.google.com/webstore/detail/web-developer/bfbameneiokkgbdmiekhjnmfkcnldhhm?hl=en)
- Firefox Developer: (https://firefox-dev.tools/)
- Chrome Developer: (https://developer.chrome.com/docs/devtools/)
- W3C Validator: (https://validator.w3.org/)
- WAVE (Firefox): (https://addons.mozilla.org/de/firefox/addon/wave-accessibility-tool/)
- WAVE (Chrome): (https://chrome.google.com/webstore/detail/wave-evaluation-tool/jbbplnpkjmmeebjpijfedlgcdilocofh)
- NVDA: (https://www.nvaccess.org/)
- JAWS: (https://www.freedomscientific.com/products/software/jaws/)

4.6.3. Using Accessibility Overlay Tools

The European Disability Forum (EDF) and International Association of Accessibility Professionals (IAAP) issued a joint statement[67] clarifying the limitations of a technology known as 'accessibility overlay'. They warned that this technology does not make websites accessible or compliant with European accessibility legislation.

[67] Statement of IAAP and EDF: (https://www.edf-feph.org/accessibility-overlays-dont-guarantee-compliance-with-european-legislation/)

Accessibility overlays enable users to change the way online content looks. While this can help some people, similar features are already available in today's browsers and devices. But some overlays can interfere with assistive technology people with disabilities use to access online content.
The problem is that many public and private online services are now using accessibility overlays instead of fixing their website to ensure it complies with accessibility laws and digital accessibility standards.
In the statement the IAAT and EDF advice buyers of technology to actively engage with digital accessibility experts, persons with disabilities and their representative organisations to understand user needs and how these can be met.

The underlying cause is the difficulty to understand what accessibility overlays can and can't deliver, and the limitations and potential risks of any new technology. Website owners who are not digital accessibility specialists may be led to believe that overlays can 'fix' the accessibility of a website, which is not the case.

5. Software Accessibility

5.1. What is Software Accessibility?

Software accessibility refers to ensuring that people with disabilities can use and access software, regardless of the type of software or the platform it runs on. Software comes in many different forms, such as classic desktop applications like WIMP, mobile applications for Android and iOS, and different operating systems like Windows, MacOS, and Linux. There are also cross-platform apps that can run on multiple operating systems, as well as progressive web apps that blur the lines between traditional desktop and mobile applications and web content.

5.2. Who benefits from Software Accessibility?

Accessibility benefits a wide range of people, including those with disabilities such as blindness, visual impairment (including colour blindness), learning disabilities, motor impairments, and more. However, accessibility also benefits elderly people and anyone who may have difficulty using technology due to age-related or other factors. By designing software with accessibility in mind, developers can create products that are easier and more intuitive to use for everyone.
Furthermore, accessibility is not just a moral imperative or legal requirement, but it also makes good business sense. By making their software accessible, companies can expand their customer base and improve user satisfaction, leading to greater customer loyalty and higher profits.

5.3. History of Software Accessibility

The history of software accessibility can be traced back to the early days of computing, when accessibility was primarily focused on physical access to the hardware. As software became more sophisticated, however, new barriers to accessibility emerged, including visual and auditory barriers, as well as those related to cognitive and physical disabilities.

In response to these challenges, a number of initiatives were launched to promote software accessibility. One of the earliest was the Rehabilitation Act of 1973, which required federal agencies to make their electronic and information technology accessible to people with disabilities.

Over time, other organisations and standards bodies also became involved in promoting software accessibility, including the World Wide Web Consortium (W3C), which developed the Web Content Accessibility Guidelines (WCAG), and the European Telecommunications Standards Institute (ETSI), which developed the EN 301 549 standard for accessibility requirements for ICT products and services.

Today, software accessibility is recognized as an important area of focus for both the public and private sectors, with many organisations working to ensure that their software is accessible to as wide a range of users as possible. This includes not only complying with accessibility standards and guidelines, but also incorporating accessibility considerations into the software development process from the outset. By doing so, organisations can help ensure that their software is as inclusive and accessible as possible, and that all users are able to benefit from the full range of features and functionality that it provides.

5.4. Most important issues to consider

5.4.1. Keyboard Shortcuts

Making keyboard shortcuts available to users is crucial for accessibility. Not only do keyboard shortcuts make using software faster and more efficient, but they also enable users with motor impairments to navigate without requiring a pointing device. Additionally, screen reader support is necessary for users with visual impairments. High-contrast display options are also important for people with colour blindness or low vision.

5.4.2. Keyboard Access

Keyboard access is vital for users who are unable to use a pointing device. All actions in software should be accessible via the keyboard, and developers should avoid interfering with the keyboard accessibility features built into the operating system.

5.4.3. Object Information

Providing a visual focus indicator is essential, particularly for custom controls. This allows users to see where they are interacting with the software. Semantic information should also be provided, including the name, role, value, and state of user interface objects. It's also

important to associate labels with controls, objects, icons, and images. Electronic forms should be designed to be accessible to people using assistive technology.

5.4.4. Sounds and Multimedia

Audio alerts are common in software, but they can be problematic for users who are deaf or hard of hearing. Therefore, it's important to provide the option to display visual cues for all audio alerts. Accessible alternatives to significant audio and video content should also be provided, and users should be able to adjust the volume.

5.4.5. Display

Colour can be used as an enhancement, but it's important to support system settings for high contrast. Additionally, software should inherit system settings for font, size, and colour. A non-animated presentation mode should be available, or standard system animations should be used. It's also important to allow users to adjust the response times on timed instructions or allow the instructions to persist. Finally, flashing or blinking text, objects, or other elements that have a flash or blink frequency greater than 2 Hz and lower than 55 Hz should be avoided.

5.4.6. Complexity of text and other content

Adapting the complexity of text and other content is crucial when considering the target audience. Several factors come into play, including age, language proficiency, and limited communication capabilities in the context of cognitive disabilities. It is essential to ensure that the information presented is accessible, understandable, and engaging for individuals based on their specific needs and abilities. By tailoring the complexity, we can effectively communicate and include diverse audiences, promoting inclusivity and comprehension.

5.5. Software Accessibility Evaluation

Easy accessibility tests can be performed by anyone to check the accessibility of software. These tests can help identify potential accessibility barriers and ensure that the software is usable for all users.

One simple test is to turn off the screen and navigate the software using only a keyboard. This test can help identify if all actions are accessible via the keyboard, and if the software provides enough feedback for users to interact with the interface without visual cues.

Screen readers are another important tool for accessibility testing. A screen reader is a software application that converts on-screen text to synthesised speech, allowing users with visual impairments to navigate the interface. By using a screen reader, it's possible to identify if all interface elements have appropriate labels, and if the interface provides sufficient feedback to users.

Alternative input methods, such as using a keyboard with smart devices, can also be used to test accessibility. Many users with motor impairments rely on alternative input methods to

navigate software. Testing software with alternative input methods can help identify potential accessibility barriers and ensure that the software is usable for all users.

Finally, disabling sound can help identify if the software provides sufficient visual feedback for users who are deaf or hard of hearing. Providing accessible alternatives to audio content is important for ensuring that all users can interact with the software.

5.6. Usual Barriers

As technology continues to advance, accessibility is becoming more important than ever before. However, there are still a number of barriers that exist in software development that prevent applications from being fully accessible to all users. One such barrier is the use of custom system controls that do not support accessibility. Another is the failure to implement the accessibility features that are provided by standard system controls. Additionally, some barriers are inherent to the design of the interface itself and cannot be easily avoided by platform providers - for example, making maps accessible can be a challenge.

To overcome these barriers, it's crucial to use and support the accessibility features that are available. Unfortunately, many software development projects do not embed accessibility into the development process from the beginning. Instead, it is often an afterthought that is only considered during user testing or, worse, only addressed if end-users are facing issues. To truly prioritise accessibility, it must be integrated into every stage of software development, from design to testing to release, similarly to requirements engineering.

5.7. Standards and International Guidelines

5.7.1. WCAG/W3C/WAI

WCAG (Web Content Accessibility Guidelines) is a set of guidelines developed by the World Wide Web Consortium (W3C) to provide a standardised approach to web accessibility. Its purpose is to make web content more accessible to people with disabilities, including visual, auditory, physical, speech, cognitive, and neurological disabilities. The WCAG guidelines cover a wide range of areas such as text alternatives for non-text content, keyboard accessibility, colour contrast, and more. Although its main focus is web accessibility, many of its criteria can also be applied to the context of software accessibility.

5.7.2. EN 301 549

On the other hand, the EN 301 549 standard specifically covers a much broader field as it is developed to provide accessibility requirements for ICT products and services. This standard has as one of its roots WCAG, but it goes beyond web accessibility and covers a broader range of facets. Its specific parts contain: software accessibility, including the accessibility of software applications, software documentation, and hardware products that are interconnected with software. The EN 301 549 standard is based on the European standardisation process and was developed by the European Telecommunications

Standards Institute (ETSI) in collaboration with the European Disability Forum (EDF) and other stakeholders. It provides a framework for organisations to evaluate and improve the accessibility of their software products, ensuring that they are accessible to people with disabilities.

5.7.3. ISO 9241-171:2008: Ergonomics of human-system interaction

ISO 9241-171:2008[68] is a part of the International Organization for Standardization's (ISO) 9241 series, which provides guidelines for human-computer interaction (HCI) and user experience (UX) design. Specifically, ISO 9241-171:2008 focuses on the accessibility of software user interfaces, providing guidance on designing software that is accessible to a wide range of users, including those with disabilities. It covers topics such as visual, auditory, and cognitive accessibility, as well as keyboard accessibility and documentation requirements.

5.7.4. Vendor/Platform Specific Guidelines, Concepts, Techniques and Tools

Platform providers offer resources to support accessibility, but these resources are limited in scope and may not cover all aspects of accessibility. Specifically, platform providers typically offer the following:

- **Tutorials for integrated accessibility features:** Platform providers often offer tutorials that cover the integrated accessibility features of their products, such as screen readers, high contrast modes, and magnification tools and allow new or existing users to get more familiar with the tools at hand.
- **Developer support for accessibility features:** Platform providers also offer support for developers to implement accessibility features in their applications. This support may include documentation and tools that help developers understand how to use the accessibility features of the platform. However, this support does not cover all aspects of accessibility or all criteria of EN 301 549 or WCAG. To ensure full accessibility, it is important to consider both platform-specific resources and international guidelines and standards. Platform-specific resources can provide helpful guidance for the specific implementation and tools for this very platform, but international standards like EN 301 549 and WCAG are comprehensive and cover a broader range of accessibility criteria. By considering both resources, developers can ensure that their applications are fully accessible and meet the needs of all users.

Microsoft:

- General accessibility introduction for MS consumer products: (https://www.microsoft.com/en-us/accessibility)
- Overview of accessibility technologies: (https://learn.microsoft.com/en-us/windows/apps/design/accessibility/accessibility)

[68] ISO 9241-171:2008 (https://www.iso.org/standard/39080.html)

- Development guide: (https://learn.microsoft.com/en-us/windows/apps/design/accessibility/developing-inclusive-windows-apps)
- Accessibility Checklist: (https://learn.microsoft.com/en-us/windows/apps/design/accessibility/accessibility-checklist)

Apple (MacOS and iOS)

- General accessibility introduction for Apple consumer products: (https://www.apple.com/accessibility/)
- Tutorials for developers and content creators: (https://developer.apple.com/accessibility/)

Linux - KDE:

- General starting point for KDE accessibility: (https://community.kde.org/Accessibility)
- Developer guide: (https://develop.kde.org/hig/accessibility/)
- QT accessibility guide: (https://doc.qt.io/qt-5/accessible.html)

Linux - GNOME:

- General starting point for Gnome accessibility: (https://wiki.gnome.org/Accessibility)
- Gnome Accessibility Technology: (https://help.gnome.org/users/gnome-help/stable/a11y.html)
- GTK accessibility guide: (https://docs.gtk.org/gtk4/section-accessibility.html)

Linux - Ubuntu:

- Accessibility Technology in Ubuntu: (https://help.ubuntu.com/stable/ubuntu-help/a11y.html.en)

Google (Android)

- General accessibility introduction for Android: (https://support.google.com/accessibility/android/answer/6006564?hl=en)
- Tutorials for developers and content creators: (https://developer.android.com/guide/topics/ui/accessibility)

Telecommunication/cooperation

- Zoom: (https://explore.zoom.us/en/accessibility/)
- MS Teams: (https://support.microsoft.com/en-us/office/accessibility-tips-for-inclusive-microsoft-teams-meetings-and-live-events-fa0cb694-0fcd-4019-b67c-8270ea4e0c54)
- Webex: (https://www.webex.com/accessibility.html)

5.7.5. CEN/CENELEC EN 17161

Accessibility follows a Design for All approach in products, goods and services and therefore extends the range of users. EN 17161 is a consistent way for organisations to manage accessibility through a Design for All approach, so that products and services can be accessed, understood and used by all people.

The standard EN 17161[69] was managed by the Strategic Advisory Group on Accessibility (SAGA) under Mandate 473 from the European Commission and describes the requirements on inclusive processes, and will be instrumental for EEA in the future (next to EN 301 549).

6. Non Classical / Future User Interfaces

6.1. Wearables

Wearables can have a significant impact on accessibility by providing new ways for people with disabilities to interact with technology. For example, wearables like smartwatches can offer vibrating or audio feedback for notifications, making it easier for people with hearing impairments to stay connected. Wearable devices can also track movement and provide haptic feedback, which can assist people with mobility impairments or blindness.
Wearables can be made accessible in various ways. One way is to ensure that the interface and display are customizable with features like high contrast settings, large fonts, and alternative input methods. Wearable apps and software should also follow accessibility guidelines such as the Web Content Accessibility Guidelines (WCAG) to ensure that they are usable for people with disabilities.
Another important consideration for wearable accessibility is the availability of third-party apps and hardware add-ons. Third-party developers can create apps that extend the functionality of wearables, such as apps for speech recognition or communication aids for people with speech impairments. Hardware add-ons can also be used to enhance accessibility, such as the use of specialised sensors to detect and alert users to obstacles in their path.

6.2. Tangibles

Tangibles, also known as tangible user interfaces, are physical objects that can be manipulated to interact with technology. They are becoming increasingly popular in a variety of settings, from education to gaming to rehabilitation. Tangibles can also be an effective way to make technology more accessible for individuals with disabilities.

For example, tangibles can be used to provide tactile feedback for individuals with visual impairments. They can also be designed to be larger and easier to manipulate for individuals with motor disabilities. Additionally, tangibles can provide a more engaging and interactive experience for individuals with cognitive disabilities.

To make tangibles more accessible, designers should consider factors such as size, shape, texture, and colour contrast. They should also ensure that any digital interfaces associated with the tangibles are accessible, such as providing alternative text for images or captions

[69] CEN/CENELEC EN 17161 (https://www.cencenelec.eu/areas-of-work/cen-cenelec-topics/accessibility/design-for-all/)

for videos. Testing with individuals with disabilities can also help identify and address any accessibility barriers.

6.3. Natural Language Interaction

Natural Language Interaction (NLI) is a technology that enables users to interact with devices or software using natural language, such as spoken or written language. This can be particularly useful for individuals with disabilities that affect their ability to use traditional input devices like a keyboard or mouse.
NLI can improve accessibility by allowing users to interact with technology in a more natural and intuitive way, reducing the need for complex interfaces or specific device interactions. For example, individuals with physical disabilities may have difficulty typing on a keyboard, but could use NLI to operate their computer or smartphone through voice commands.
To make NLI more accessible, developers need to ensure that the language recognition and response systems are designed to accommodate a range of different accents, dialects, and speech patterns. Additionally, it's important to provide alternative means of interaction for users who may not be able to speak or hear, such as through text-based chatbots or gesture recognition.

6.4. XR/VR/AR

Extended Reality (XR) technologies such as Virtual Reality (VR) and Augmented Reality (AR) have a unique potential to enhance accessibility for people with disabilities. For example, VR can be used to simulate real-life experiences, providing a safe environment for people with physical or cognitive disabilities to practise activities that may be difficult or impossible to perform in real life. AR can be used to overlay information onto real-world objects, making them more accessible to people with visual impairments.
However, XR technologies also present significant challenges to accessibility. VR headsets can be difficult or impossible for people with certain disabilities to use, and some individuals may experience motion sickness or other negative effects. AR experiences can be visually overwhelming, making it difficult for people with cognitive or sensory processing disabilities to process the information.
To make XR/VR/AR more accessible, designers and developers should consider the diverse needs of users with disabilities in the design process. This may include providing customizable settings for visuals, audio, and controls, ensuring compatibility with assistive technologies such as screen readers and switch controls, and providing clear and concise instructions and feedback. Additionally, designers and developers should consult with people with disabilities to ensure that the XR/VR/AR experience is as accessible and inclusive as possible.

6.5. Home Automation/Smart Home/IOT

Home Automation, Smart Home, and IoT (Internet of Things) refer to the network of smart devices that are connected and controlled through the internet. These technologies can significantly improve the quality of life for people with disabilities by providing them with a more accessible and convenient living environment.

For instance, smart home systems can automate tasks such as turning on lights, adjusting the thermostat, opening doors, or even making a cup of coffee. These tasks can be especially challenging for people with mobility or sensory impairments, making home automation technology a significant benefit.
To make Home Automation, Smart Home, and IoT accessible, designers and developers must ensure that these devices and systems are usable and configurable by people with disabilities. For instance, voice-activated commands, tactile feedback, and easy-to-use interfaces can enhance accessibility. Also, it is essential to ensure that smart devices are interoperable, i.e., can work together, and are compatible with assistive technologies such as screen readers and speech recognition software.
Designers and developers should follow accessibility guidelines, such as EN 301 549 or WCAG, to ensure that smart home devices and systems are accessible. In addition, companies should consult with users with disabilities during the design and development process to ensure that their needs are being addressed.

6.6. Consumer Electronics (kitchen, TV, audio, medical/care environments)

Consumer electronics such as kitchen appliances, TVs, audio devices, bathroom fixtures, and medical/care equipment can have accessibility challenges for individuals with disabilities. For example, a person with low vision may have difficulty reading the labels on kitchen appliances or adjusting the settings on a TV. Someone with limited mobility may struggle to use a traditional remote control or operate a bathroom fixture.
To make consumer electronics more accessible, manufacturers can incorporate features such as large and high-contrast displays, tactile controls, voice recognition, and compatibility with assistive technologies. For example, a smart TV with a voice-controlled remote can be more accessible for people with limited dexterity or visual impairments. Similarly, a bathroom fixture with a touchless control system can be easier to use for someone with limited mobility.

6.7. SST/ATMs

Self-Service Terminals (SSTs) and Automated Teller Machines (ATMs) are commonly used in banking and retail industries for transactions such as withdrawals, deposits, and bill payments. To make these machines accessible the EN 301 549 can be easily applied and therefore plays a crucial role for ensuring equal access to financial services.

To make SSTs and ATMs accessible, several measures can be taken. For example, providing tactile buttons and audio instructions for users who are blind or visually impaired, ensuring that touchscreens are responsive and large enough to accommodate users with motor disabilities, and offering adjustable heights and positions for wheelchair users. In addition, some machines are equipped with speech recognition software that allows users to complete transactions through natural language interaction, and some may have Braille labels or audio jacks for headphones.

It's important for SSTs and ATMs to comply with accessibility standards, such as the Americans with Disabilities Act (ADA)[70] in the US or the Web Content Accessibility Guidelines (WCAG) for digital content. Testing and evaluation of accessibility by people with disabilities can help ensure that these machines are fully accessible to everyone.

[70] Americans with Disabilities Act (https://www.ada.gov/)