Proposal of new WCAG success criteria for Mobile accessibility

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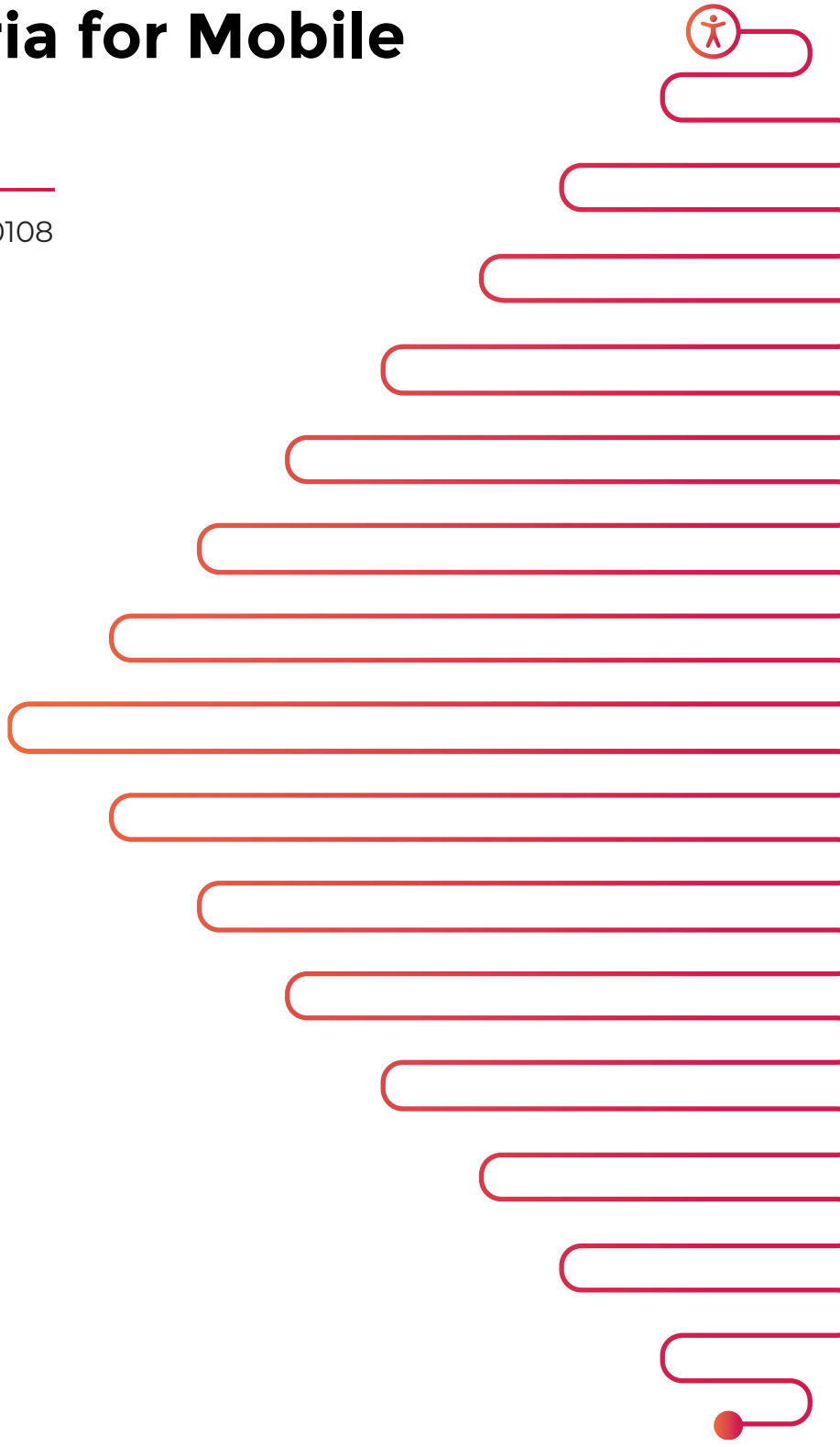

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Abstract (en)

This research proposes new success criteria for the Web Content Accessibility Guidelines (WCAG) focusing on improving Mobile accessibility. The execution of a quick evaluation of the current regulation for digital accessibility led us to use WCAG as the main reference frame for the research since they are the baseline for the European and American Standards. WCAG tries to keep the proposed guidelines device-independent. However, the analysis of the specific characteristics of mobile devices presents new opportunities for the improvement of digital accessibility. This study includes also the exploration of the accessibility recommendations provided by the main mobile Operating Systems (iOs, Android and Windows) that could be considered part of the background information used for the proposal of new success criteria. The first results consisted of the proposal of five success criteria structured following the example of WCAG addressing the statement, the intention, the benefits and recommendations for implementation. The suitability and details of this proposal were validated and improved thanks to the performance of interviews with experts in the field. The outcome of the study is the second iteration of the proposal applying the feedback obtained, conformed of three new WCAG success criteria: 1.4.A Enable Dark mode, 1.4.B Minimum font size and 1.4.C High-resolution image; and two extensions to existing ones: 2.1.4 Character key shortcut: Enable speech input and 3.3.7 Accessible authentication: Alternative to biometric authentication. The conclusions highlight the importance of further development of these criteria through coding and practical validation, since the study has been done focusing on the impact of design aspects, and remark the potential benefits of the application of the proposal on diverse functional categories and systems.

Keywords

Digital accessibility - WCAG - Mobile devices

Abstract (it)

Questa ricerca propone nuovi criteri di successo per le Linee guida per l'accessibilità dei contenuti Web (WCAG) concentrandosi sul miglioramento dell'accessibilità mobile. L'esecuzione di una rapida valutazione dell'attuale normativa per l'accessibilità digitale ci ha portato ad utilizzare le WCAG come principale quadro di riferimento per la ricerca in quanto baseline per gli Standard Europei e Americani. WCAG è pensata per con l'intento di strutturare le linee guida indipendenti dal dispositivo. Tuttavia, l'analisi delle caratteristiche specifiche dei dispositivi mobili – che hanno differenze sostanziali rispetto ai desktop – presenta nuove opportunità per il miglioramento dell'accessibilità digitale. Questo studio presenta anche un'analisi delle raccomandazioni di accessibilità fornite dai principali Sistemi Operativi mobili (iOs, Android e Windows) che, insieme all'applicazione sperimentale dei criteri correnti, ci hanno permesso di strutturare una proposta di nuovi criteri di successo. Il primo round di analisi ha generato cinque criteri di successo, strutturati come prevede la sintassi delle WCAG che comprendono 4 elementi per ogni criterio: la dichiarazione, l'intenzione, i benefici e le raccomandazioni per l'attuazione. L'idoneità e i dettagli di questa proposta sono stati convalidati e migliorati grazie allo svolgimento di interviste con esperti del settore. Il risultato dello studio è la seconda iterazione della proposta applicando il feedback ottenuto, conforme a tre nuovi criteri di successo WCAG: 1.4.A Abilita modalità Dark, 1.4.B Dimensione minima del carattere e 1.4.C Immagine ad alta risoluzione; e due estensioni a quelle esistenti: 2.1.4 Tasti di scelta rapida: Abilita input vocale e 3.3.7 Autenticazione accessibile: Alternativa all'autenticazione biometrica. Le conclusioni sottolineano l'importanza di un ulteriore sviluppo di questi criteri attraverso la codifica e la convalida pratica, poiché lo studio è stato condotto concentrandosi sull'impatto degli aspetti di progettazione e sottolineano i potenziali benefici dell'applicazione della proposta su diverse categorie funzionali e sistemi.

Keywords

Accessibilità digitale - WCAG - Dispositivi mobili

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Secondly, to the experts Roberto Scano, Alejandro Moledo del Río and Sheri Byrne Haber, who decided to take some time for me and invest in my thesis, providing me with valuable insights, feedback and sharing their experience, encouraging me to go further than my thesis and recognizing the value of my work.

Finally, I have to thank my parents and my sister for the support and opportunities they have always provided me to reach this point. For caring about the excellence of my education. To Sef, Farshad, Irmak and all the friends that kept me calm and were always ready to help.

Let's work to leave this world a little better than we found it!
(R. Baden Powell)

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List of acronyms:

ARIA - Accessible Rich Internet Applications

ATAG - Authoring Tool Accessibility Guidelines

EU - European Union

ICT - Information and Communication Technology

IOS - International Organization for Standardization

SC - success criteria

UAAG - User Agent Accessibility Guidelines 2.0

UI - User Interface

UX - User Experience

W3C - World Wide Web Consortium

WAI - Web Accessibility Initiative

WCAG - Web Content Accessibility Guidelines

WHO - World Health Organization

XR - Extended Reality

Introduction

Before we start:

Introduction:

The following research proposes a compendium of guidelines for designing accessible Mobile Applications based on the analysis of the currently applicable Standards within the European Union (from now on EU) and including the inputs and recommendations provided by Apple (iOS), Google Material Library (Android) and Microsoft (Windows) as creators of the main operating systems for Mobile devices

The ISO 20800:2011 on Ergonomics, General approach, principles and concepts defines accessibility as "the extent to which products, systems, services, environments and facilities can be used by people from a population with the widest range of characteristics and capabilities, to achieve a specified goal in a specified context of use" (ISO 26800). If we bring the definition to the context of Mobile Applications, Mobile accessibility refers to "making websites and applications more accessible to people with disabilities when they are using mobile phones and other devices" (W3C - (WAI), 2020). In this definition, "other devices"

"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 characteristics and capabilities, to achieve a specified goal in a specified context of use" (ISO 26800)

includes not only phones but tablets, wearables, smartwatches, devices in car dashboards and airplanes seatbacks, smart Tvs, devices in households appliances and other devices considering the "Internet of things" which share several characteristics such as reduced display surfaces, touchscreens and different inputs modalities (W3C - (WAI), 2020).

The research is divided into four main chapters. Firstly, the design challenge outline, which identifies the added value of accessibility for Mobile Applications, their importance and relation with the product design field and the need for the performance of this research.

Secondly, the analysis of the different current applicable regulations regarding the accessibility of Information and Communication Technology (from now on ICT) and the relation between them; particularly explaining the choice of WCAG 2.1 as a main reference and centre of the analysis.

The third chapter focuses on mobile devices, presenting a short summary of how the regulations apply and the specific conditions that characterize the use of Mobile devices.

Finally, the fourth and more relevant chapter identifies pain points and topics whose consideration as part of future WCAG for Mobile phones would have a positive impact, proposing them based on the specific characteristics of Mobile devices previously stated and the current trends on usability and User Experience. We also consider the accessibility guidelines proposed by the main Mobile operating systems, iOS, Android and Microsoft focusing on the possible implementation of the new guidelines proposed. The first iteration of the five generated success criteria has been contrasted with four experts in the field by performing interviews to validate their interests and improve them. Thanks to the feedback obtained through these interviews a second iteration of the criteria is presented. After the proposal and validation, we present a reflection on future lines to be explored by WAI to broaden the accessibility of digital technologies and the conclusions of the research performed.

Impact of Mobile accessibility on Product Design

In the last decades, products have become more and more complex, including in many cases not only hardware but a great number of electrical components, sensors, microprocessors, and systems for data collection that can amplify the range of functions that a product can provide and broaden the business opportunities in the market. The "Internet of things' ' represents the capacity of smart products to connect, interact and exchange information improving the capability of the products. By incorporating smart components they can improve the performance and gather more data that thanks to the connectivity can enter into the system to provide new functionalities, provide feedback and improve the experience (Porter & Heppelmann, 2014).

Thanks to sensors, data and artificial intelligence many products in the market can automate their performance to adapt to the user's need, such as ceiling fans that set the speed and working time according to the ambient conditions in the room. However, in many cases, the interaction is supported by a digital product, such as a Mobile Application that provides the new services and data gathered or help to control and set the products.

Leaving aside the economic factor, the rise of smart products has led to the inclusion of new considerations as part of the design process such as the involvement of a new dimension on the User Experience: the digital interaction. When it comes to accessibility, it means that not only should we consider the accessibility of the hardware and physical product but the digital to ensure the integration of both aspects within the product. Under this motivation, I decided to explore in further detail the guidelines and recommendations in force and evaluate their impact on Mobile Native Apps.

Chapter 1:

Framing the problem

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The World Health Organization (WHO) estimates that about 15% of the world's population, more or less 1 billion people, lives with some kind of disability. Moreover, 3.8%, 190 million people 15 years old or older suffer remarkable difficulties in functioning (World Health Organization, 2020). The WHO presents disability as" the umbrella term for impairments, activity limitations and participation restrictions, referring to the negative aspects of the interaction between an individual (with a health condition) and that individual's contextual factors (environmental and personal factors)" (World Health Organization, 2011). This approach presents disability as a complex and dynamic interaction between personal health and environmental and contextual conditions, meaning that disability is not a personal attribute but a result of personal capabilities and situational factors.

In fact, the impairments and limitations do not only refer to permanent conditions but also temporary or situational ones. Following the example provided by the Inclusive Design Toolkit (Microsoft Design, 2016), we can better understand environmental facts (Figure 1). A mismatch between the personal capabilities and the environment regarding touch

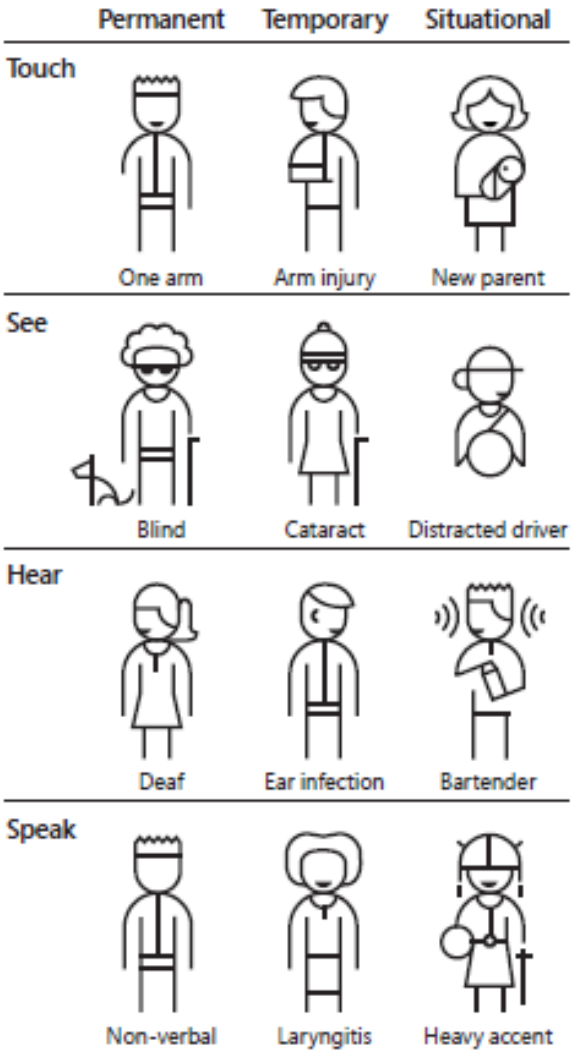

Figure 1. Illustrated classification of disabilities (Microsoft Design, 2016).

can appear in a permanent way, such as the absence or loss of one of the arms or hands, but it could also be something temporary if one breaks an arm and needs to carry it in a cast, or even situational if one is holding a baby or a heavy package. In the same way, we can find the classification of permanent, temporary and situational limitations for sight, hearing and speech. By providing accessibility to people with permanent difficulties we are also providing it to the ones who suffer from temporary or situational, remarkably increasing the number of users that benefit from it; for example, captions can be useful for deaf people, but also for the ones who are in a highly noisy or quiet environment.

In 2003, Microsoft Corporation commissioned Forrester Research, conducted a study on the benefits of accessible technology for computers aiming to measure the potential market of users that would be likely to benefit from it. Accessible technology would allow the users to adapt the system (both hardware and software) to their specific visual, cognitive, hearing, dexterity or speech needs. The study focused on adults of working age (18 to 64 years old) in the United States and tried to evaluate their potential benefits according to the different levels of impairments they suffered. It not only focused on those who claimed to have an impairment but also included users who claimed not to have any difficulty on performing computer tasks, dividing them into three categories: Not likely, likely or very likely to benefit from the use of accessible technology due to no or minimal, mild or severe difficulties or impairments respectively. In total, 60% of the participants were likely (38%) or very likely (22%) to benefit from them, which is more than half of the users.

The final output of this research shows that, rather than dividing the population into two groups, able-bodied and disabled, we should

consider a wider range. Not all people with disabilities have the same kind and amount of difficulties and not all the difficulties have the same level. This is represented in the pyramid model of diversity (Figure 2), which segments the population in several user categories starting from users without any difficulties and positioning those with severe ones in the peak. In this case, only the base of the pyramid, the 21% do not have any difficulty. The environmental and situational factors could nevertheless provide these 21% temporary or situational difficulties, therefore, we can understand the importance of accessibility and its benefits for everyone (University of Cambridge, 2021).

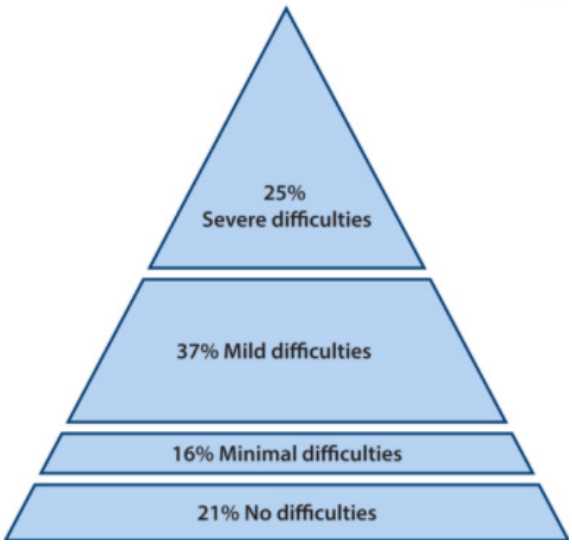

Figure 2. Pyramid model of diversity (University of Cambridge, 2021).

However, while urban accessibility seems to be addressed by governmental regulations and standards, ICT accessibility is not that frequently highlighted. In addition, ICT affects a great number of services, products and systems, involving a great variety of stakeholders and increasing the complexity of its consistent application (World Health Organization, 2011). The majority of the countries take Web Content Accessibility Guidelines (WCAG) developed by the Web Accessibility Initiative (WAI) as a Standard for web accessibility. In fact, WCAG 2.0 has now been adopted by the International Organization for Standardization (IOS). There is now an effort in the development of harmonized guidelines between the United State Section 508 and WCAG 2.0 accessible requirements and the drafting of a further version to move towards a common Standard and update the information to the newest technology (Lawson, 2017).

The WCAG 2.0 was developed in 2008 and since then the ICT has experienced a remarkable amount of changes and evolutions, especially regarding the use of Mobile phones. By 2017 more than 5 billion people were connected to mobile services, expecting this number to reach 5.9 billion by 2025, which represents 71% of the world's population (Thomson, 2018). In 2020, the number of users of smartphones will reach 3.5 billion (Iqbal, 2020). In fact, in 2019 the time spent by the average US adult watching TV was 3 hours and 45 minutes, being overcome by the time

spent using mobile devices (3 hours and 43 minutes) (Wurmser, 2019). 80% of the time spent using mobile devices corresponds to the use of Mobile Apps (Smart Insights, 2020). Reports on consumers preferences indicate that 85% of the users prefer mobile apps to mobile websites (Moth, 2013). We can picture more clearly the relevance of Mobile Apps by looking at the number of alternatives in the market and their shares and downloads. In 2019, the main app stores available were Google Play Store, which offers 3.3 million Android Apps (Dogtiev, 2021) and Apple's App Store with 2.2 iOS million Apps. The app revenue covering both of them escalated to 31.9 billion dollars in the last quarter of 2020 being 10.4 billion dollars for Android and 21.4 billion dollars for iOS (Curry, 2021).

The WCAG 2.0 provides an adaptation of the general guidelines for Mobile devices establishing that "All the advice in this document can be applied to mobile web sites, mobile web applications, and hybrid web-native applications. Most of the advice also applies to native applications (also known as "mobile apps'')" (W3C, 2015). In 2020, W3C published the Roadmap of Web Applications on Mobile as well as recommendations, tutorials and best practices for Mobile Web Applications (W3C, 2014).

As leaders in the sector, Apple and Google offer some guidelines for the design of accessible Mobile Apps, providing resources on the Human Interface Guidelines for Apple and Material Library from Google in order to encourage designers and developers to be consistent with the look for accessibility they drive. Another reference in the sector is Microsoft, which sees accessibility as an enabler of transformative change and also provides a set of guidelines for designing accessible apps (Microsoft, 2021).

In consequence, there are a remarkable number of proposals and guidelines for accessibility on mobile apps, providing different resources and strategies to overcome disabilities but without an existing harmonized Standard that could simplify the user's experience and move together towards Mobile accessibility; while WCAG does not have a detailed set of guidelines specifically adapted to safeguard mobile accessibility.

1.1 Aim of the Research

The research aims to identify pain points and possible opportunities on the application of WCAG 2.1 on Mobile devices by addressing and proposing new possible Success Criteria based on the differences in user experience between Mobile and Desktop devices. Leveraging on the current trends and the accessibility recommendations provided by the main Operating Systems in the market such as iOS (Apple), Android (Google) and Windows (Microsoft) (Hamed and Kermer, 2017).

1.2 Scope of the Research

The current documents published by WAI regarding Mobile accessibility defend the application of WCAG 2.0 and 2.1 to mobile websites, mobile web applications, and hybrid web-native applications, stating also that majority of them can be applied also to Native Mobile Apps (W3C, 2015). However, Mobile devices present distinctive characteristics that influence the user experience and behaviour requiring the implementation of specific solutions adapted to them. This thesis explores the current regulations and proposes possible new Success Criteria to be included to target them. WCAG generally confronts web accessibility issues from two different fields, design and programming.

Due to the great number of aspects that could be explored and the generation of the thesis as part of a design programme, the research will focus on issues identified from a design perspective, visual and experiential, leaving the programming vision in a second plane. As a consequence of this decision, the presentation of the new Success Criteria will follow the general structure provided by WCAG for each Success Criteria on the page “Understanding this Criteria” (Statement, Intent, Benefits and Techniques) but substituting “Sufficient techniques” by recommendations for implementation.

The evaluation of these new proposed Success Criteria has been performed by interviewing experts in the field that reviewed their potential and relevance. However, further exploration would be needed in future occasions to experimentally test the results of the Criteria and determine

the requirements, conditions and techniques from a programming perspective in order to set valid and clear Success Criteria and provide the resources needed for designers and developers to follow them.

1.3 Methodology

The development of this thesis can be divided into three steps: research, proposal and validation, in which we have leveraged the use of different tools and processes to collect the information. Between the main tools used we can find: literacy research, practical application of the regulations, analysis and critics of the regulations and interviews with experts.

Firstly, we have researched the current regulation concerning digital accessibility that has led us to set the focus on WCAG. The research has gone in-depth into the evolution, process, requirements and documents of WCAG exploring mainly the official literacy published by W3C and paying special attention to the understanding of each of the Guidelines and success criteria stated and their organization in levels. In order to fully understand the success criteria in a practical way, we have worked on a complementary task consisting of performing the accessibility audit of one of the new Design Systems proposed by Unicredit, UniCredit Omnichannel (a summary of the result of the work can be found in Annex B). The accessibility audit helped us focus on some issues and some examples of the issues found will be mentioned during the Proposal of the new success criteria.

To perform the second step, "Proposal", since we had already done a deep analysis of the success criteria we were able to identify possible working areas and opportunities for improving accessibility on mobile devices. The preliminary success criteria proposed were contrasted with the opinion of Roberto Scano, accessibility expert and member of the WCAG working group through an interview, who validated the vision, the preliminary direction of each of them and suggested improvements

for the development.

Once the preliminary success criteria were confirmed, we worked on the development of each Criterion relying on the literature available and organizing them following the structure set by WCAG in their section "Understanding this Criterion".

The third step, "Validation", consisted of performing expert interviews in which to present the completed success criteria, validate them and gather insights and feedback for improvements in order to generate a second iteration. The interviews were conducted with a total of three more experts, all of them with vast experience in accessibility and the application of WCAG, being three of them part of the WCAG working group. More information about the experts, Roberto Scano (preliminary interview), Alejandro Moledo, Sheri Byrne-Haber will be provided in subchapter 4.2 Validation. The transcription of the interviews can be found in Annex A: Experts' interviews together with the presentations used for driving the interviews. The final result of the thesis is the second iteration of the proposed success criteria generated from the starting point of improving mobile accessibility.

Chapter 2:

Context

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2.1 WCAG

2.1.1 Origin of WCAG

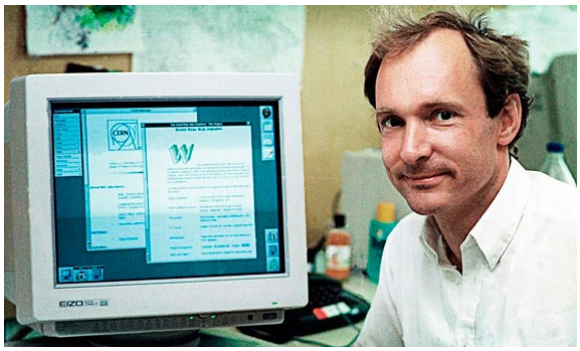

Figure 3. Tim Berners-Lee, creator of W3C.

The World Wide Web Consortium (W3C) was created in 1994 by Tim Berners-Lee (Figure 3) aiming to create standard technologies and protocols to generate web content and make it available for the largest number of people. It was developed at the Massachusetts Institute of technology counting with the support of important organizations such as the EU trying to involve multiple stakeholders to satisfy their needs. The recommendations provided by W3C are not compulsory to apply, but rather a quality assurance for one's web. However, some of them have become a reference for European or American regulations.

In 1996 an enthusiastic group of workers from W3C proposed an initiative to work for accessibility standards in order to enlarge the reach of the Web and fight the divergent and different strategies approached by developers and designers providing them with a useful solution. After 9 months of

work, they released the Web Accessibility Initiative (WAI) (Dardailler, 2009).

In order to generate resources for improving web accessibility, the WAI follows a process designed to overcome 5 milestones (working draft, wide review working draft, candidate recommendation, proposed recommendation and W3C Recommendation), and make sure that consensus, consistency and high technical quality are achieved (WAI, 2020). In addition, they perform accessibility tests with people with disabilities, embrace accessibility in the internal policies and mission (all the content must meet WCAG 2.1 AA and try to meet AAA), provide access to the resources created and state real goals to orientate each process (WAI, 2020b).

Between the standards generated by the WAI we can highlight the following:

- **Authoring Tool Accessibility Guidelines (ATAG).** Authoring tools are software tools that facilitate the production of content such as wikis, blogs, forums or social networks where developers and authors, writers, designers, photographers can easily participate (WCAG - (WAI), 2020c)

- **User Agent Accessibility Guidelines (UAAG).** It focuses on guidelines for creating accessible browsers, extensions, media players, readers and so on (W3C - (WAI), 2016)

- **Accessible Rich Internet Applications (WAI-ARIA)**. It was created for making Web Content more accessible paying attention to dynamic and advanced user interfaces controlled with HTML, JavaScript, etc. (W3C - (WAI), 2020a)

- **Web Content Accessibility Guidelines (WCAG).** It aims to make content (information provides such as images, text and sound and the structure and presentation provided by the code) more accessible (W3C - (WAI), 2021)

Each of the standards presents the Success Criteria for the guidelines according to 3 conformance levels. Level "A" is the lowest, meaning

that it is the minimal accessibility compliance. "AA" is the middle one, so acceptable compliance, usable and understandable for the majority of people with or without disabilities; and "AAA" is the maximum level, optimal compliance, being easy to use for the maximum number of users. However, complying with AAA level might require too many resources in some cases, so it cannot be generally required (Accessibility Guidelines Working Group, 2021).

The four of the areas presented play an important role in Web accessibility and are related between them. However, in this paper, we will focus on the WCAG, being the ones that are closer to UI design and visual aspects.

2.1.2 WCAG published versions

The first version of the standards, WCAG 1.0 was created in 1999, composed of 14 guidelines which included between 1 and 10 supporting checkpoints each for enhancing the clarity of the web.

In 2008, the rapid evolution of technology pushed the WAI to generate a clear structure for the development of consistent accessibility strategies that could apply recommendations analysis to different platforms arising. The result was the creations of WCAG 2.0, which sets the four basic principles for web accessibility:

- **Perceivable.** The users should be able to comprehend and perceive the content and information provided.
- **Operable.** The user must be able to complete the navigation, meaning that there cannot be interactions that the user cannot perform.
- **Understandable.** Both, the information provided and the structure and operability of the Web should be understandable to the user.
- **Robust.** The web should be flexible and consistent enough to be

> satisfactorily interpreted for different user agents and platforms, paying special attention to the compatibility with assistance technologies (W3C - (WAI), 2019).

From this point, each guideline of WCAG is assigned to one of these four principles and provides specific Success Criteria to meet them. As in other standards created by WAI, they adapt the number of testable Success Criteria to the three possible accessibility conformance levels, A, AA and AAA.

WCAG 2.0 is also approved as an ISO standard, the ISO/EIC 40500:2012 which includes exactly the same content as WCAG 2.0 (W3C - (WAI), 2021c).

One decade after the release of WCAG 2.0, in 2018, the WAI releases the WCAG 2.1 which rather than overcoming version 2.0 it works as an update, including additional information adapted to the new times. This means that if one is complying with version 2.1 will also be complying with version 2.0. The new version includes new Success Criteria focused on Cognitive Disabilities, low vision and gives more attention to Mobile Design. When it refers to WCAG previous versions are always contained in the last one (Bureau of Internet Accessibility, 2019).

2.1.3 New versions to be released

Version 2.2

The new version, WCAG 2.2 is planned to be published in 2021. So far, there is an available working draft that provides 9 new Success Criteria focusing on developing more the targets set by version 2.1: people with cognitive difficulties, low vision and Mobile devices, including topics such as accessible authentication (W3C - (WAI), 2021a). Structured following the four different principles the main changes of this version are:

- **Operable.**

  - Focus visible is changing from AA to A and requires minimum 8 pixels border on the short side or 1 pixel minimum full border around the focus, using 3:1 contrast with the background or 1 pixel minimum border around the element on focus and defining a colour contrast of 3:1 between focused and unfocused state.
  - **2.5.7 Dragging (Input modalities)** (AA). Provide alternatives to dragging based on simple pointer interaction such as moving through a slider using + and - buttons.
  - **2.5.8 Pointer target spacing** (AA). Separate components that are not inline "Small targets that are less than 44 pixels in width or height must have at least a 44-pixel high and wide selection area. For example, a 24-pixel square icon needs 10 pixels of padding on all sides (10 + 24 + 10 = 44)" (Kalcevich, 2021) one can also give the possibility to make elements bigger till reaching at least a width and height of 44 pixels.

- **Predictable.**

  - **3.2.6 Findable help** (A). Keep consistent the position of the help and contact information on the apps, webs and code.
  - **3.2.7 Hidden controls** (AA). Main actions should be visible in general conditions, one should avoid displaying options only during hovering or performing a specific movement. Alternatively, there should be a mechanism that makes visible all the options.
  - **3.3.7 Accessible authentication (Input assistance)** (A). Provide the user different ways of authenticating the identity, allow face recognition, alternative pins, third parties authentication or copy-pasting the passwords. Provide more than one option based on different cognitive function tests.
  - **3.3.8 Redundant entry (Input assistance)** (A). The user should not be required to enter the information already entered during the same process. Rather than asking the same entry twice, like residence and billing address, ask the user if they are the same

and skip the process if so.

(Kalcevich, 2021.

Version 3.0

The Accessibility Guidelines Working Group is developing in parallel to 2.2 a new version of the guidelines that include new substantial changes in the structure and aims to be more realistic, version WCAG 3.0, also called "Silver" since they are being developed by the Silver Task Force of the Accessibility Guidelines Working Group and the W3C Silver Community.

This new version will have some similarities with the previous ones, such as giving guidance and specific accessibility requirements, but will incorporate substantial differences, changing the structure, having a broader scope and proposing a different conformance model. WCAG 3.0 aims to be easier to understand, to target a bigger number of users and disabilities being able to evaluate them more precisely than true and false criteria and address more platforms paying attention to their specific needs. All of it to support more people and evolve fastly with technology. The seeking to adapt to the functional needs leads them to include some guidelines from the mentioned User Agent Accessibility Guidelines 2.0 (UAAG) and the Authoring Tool Accessibility Guidelines (ATAG). Quoting the WCAG 3.0 Draft we can appreciate the new requirements:

- Applied across technologies
- Clear conformance
- Ease of used
- Diverse audience
- Identify who benefits

The expected result of this version is an alternative set of guidelines rather than an addition to the WCAG 2.2. Once they are developed

and turned into recommendations developers and users can use them to maximize accessibility and be more aligned to future developments. Nevertheless, conforming to 3.0 will also conform to previous versions and the guidelines of 2.2 will be a part of 3.0.

Each of the new guidelines consists of plain-language statements that include different outcomes such as critical errors and outcome rating. Each of these outcomes can be referred to all the technologies, to a specific one or to emerging technologies that still do not have a defined method assigned (fallback). Each of the methods includes a description of the process, detailed examples, tests to evaluate the conformance and a scoring system to evaluate the outcomes. The final score can be analysed as an overall score or explore the relationship with the different functional categories. The result will be the classification in the quality of the accessibility in a more informative way assigning them to one of these three levels: bronze (score on the functional categories), silver and gold (additionally improved usability). The bronze category will have a similar level as WCAG AA level. As a consequence of the use of a new conformance system, some companies might decide to go on with the previous version rather than adapting the newest one (W3C - (WAI), 2021b). Since only the first draft of the WCAG 3.0 and WCAG 2.2 have been released we will focus on the analysis of the previous version, WCAG 2.1, while keeping in mind the possible outcomes coming from the new set.

2.1.4 Functional categories

The term “disability” includes a great number of situations and needs that can have nothing to do between them, being necessary to explode it into different categories that help us to analyse better the specific needs for each case. The WAI defines functional needs as “A statement that describes a specific gap in one’s ability, or a specific mismatch between ability and the designed environment or context” (W3C - (WAI), 2021d) and clarifies that they should be applied to explicit factors to be able to define the different barriers they create. Functional Categories group functional needs to fit the user’s conditions. The name of this concept

and its internal classification can vary depending on the reference or regulation consulted, but they all have the same essence. In the case of EN 301 549, they are called Functional Performance Statements and in Section 508 Functional Performance Criteria.

The current classification of Functional Categories in WCAG is composed of the following 14 classes (W3C - (WAI), 2021d):

- Speech
- Attention
- Language and Literacy
- Learning
- Memory
- Vision and Visual
- Hearing and Auditory
- Sensory Interchapters
- Mobility
- Motor
- Physical and Sensory Interchapters
- Executive
- Mental Health
- Cognitive and Sensory Interchapters

WCAG uses the Functional Categories to make sure that all the functional needs are addressed by the guidelines and make the content accessible to the maximum possible population. Each Success Criterion is stated and developed for covering the needs of one or more Functional Categories. This means that in order to be compliant with WCAG all the Success Criteria should be met. Otherwise, users belonging to some Functional Categories would not be able to access the content.

2.2 Review of the exixting official regulations

2.2.1 EN 301 549 v3.1.1 / v2.1.1

The EN 301 549 is the Harmonized European Standard on Accessibility requirements for ICT products and Services. The first version was demanded in 2005 by the European Commission with Mandate 376 aiming to harmonize the technical requirements on accessible ICT for products and services. This version was finally published in 2014 and was supported by three technical reports (TR 101 550, TR 101 551 and TR 101 552). In 2017 with the publishing of the European Directive 2016/2102 on the accessibility of the websites and mobile applications of public sector bodies the EN 301 549 needed to be updated for complying, resulting in the "EN 301 549 V2.1.2 (2018-08) Accessibility requirements for ICT products and services, elaborated by ETSI (ITU, 2019).

In order to define the accessibility and its levels, the EN 301 549 v2.1.2 gives two different tools (ITU, 2019):

- A list of 11 **Functional performance Statements** which describes in a wide mode the needs of the users:
    - Usage without vision
    - Usage with limited vision
    - Usage without perception of colour
    - Usage without hearing
    - Usage with limited hearing
    - Usage without vocal capability
    - Usage with limited manipulation or strength
    - Usage with limited reach
    - Minimize photosensitive seizure triggers
    - Usage with limited cognition
    - Privacy

- A set of testable **Functional Accessibility Requirements** for each of the Functional Performance Statements, which provides the evaluation methods and procedures for achieving them. They are classified into the following categories:

    - Generic requirements
    - ICT with two way voice communication
    - ICT with video capabilities
    - Hardware
    - Web
    - Non-web documents
    - Software
    - Documentation and support services
    - ICT providing relay or emergency service access

In Annex B of the EN 301 549 v2.1.2 we can find a table showing which Functional Performance Statement is tackled by each Requirement. This highlights the fact that in order to be compliant all the Requirements need to be fulfilled. Otherwise, people with issues belonging to some Functional Performing categories might still have difficulties.

One of the most significant changes of the EN 301 549 2.1.2 is the adoption of the WCAG 2.1. for web content, electronic documents and non-web software (such as native Mobile Apps). Rather than containing the WCAG 2.1 as an attachment, it is directly referencing them in order to avoid duplicity and centralize the requirements (Abou-Zahra, 2018).

In Annex A of the standard, we can find the relation and presumption of conformity between the requirements expressed and the ones that can be found in the Directive 2016/2102. The first table (Table A.1) of that document presents the relation within web pages, while Table A.2 refers to Mobile applications and to all the content included in the software (textual, non-textual, content to be downloaded, payment processes, authentication and two-way interaction). Some of the proposed Success Criteria appearing in chapter 4 of the present thesis document are already reflected in Table A.2 (ETSI, 2019).

EN 301 549 are currently being revised for updating. The draft version of EN 301 549 v3.1.1 was released in June 2019 (ETSI, 2019).

2.2.2 DIRECTIVE 2016/2102

The full name of this directive is Directive 2016/2102 of the European Parliament and of the Council of 26 October 2016 on the accessibility of the websites and mobile applications of public sector bodies. The fact that it is a directive means that it is not automatically adopted as a law for the countries of the EU, but rather each country needs to include its content into the national laws, setting the minimum requirements but allowing the countries to create further regulation. (European Union, no date).

The Member States shall ensure that public sector bodies take the necessary measures to make their websites and mobile applications more accessible following the four principles of accessibility proposed by WCAG 2.1: perceivable, operable, understandable and robust(Springer, 2016). As it was established, by September 2018 all the States members should have prepared the implementation laws and by December 2018 publish the accessibility statement. According to the timeline set, by 2021 all the Mobile Applications of public sectors must be accessible (European Union, no date). The requirements include an accessibility statement (information of the inaccessible elements and alternatives), the monitoring of the system and the reporting resulting from the monitoring (Monsido, 2019).

2.2.3 Section 508

In 1998, the United States Congress amended the Rehabilitation Act to require electronic and information technologies to be accessible for people with disabilities to apply for federal agencies. Under Section 508, the U.S. Access Board developed standards on accessibility to be included in the regulation for Federal agencies (GSA Government, 2020a). It ensures accessibility for people with cognitive, sensory or physical disabilities and covers not only computers but also general office equipment such as printers, copiers, kiosks or electronic documents (US Access Board, 2017).

The final rule which updated the accessibility requirements was finally

issued in 2017 and effective in 2018 aiming to comply with the market evolution, innovation and trends. In addition, the revised version of the standards on Section 508 and the guidelines of Section 255 of the communication Act takes one step further harmonizing the guidelines with the mentioned European regulation and European references such as WCAG from W3C (GSA Government, 2020a).

The U.S Access Board claims that both, Section 508 and WCAG share the same objective: making ICT accessible for everyone. In fact, Section 508 directly references WCAG 2.0 in the level of conformance A and AA. The U.S. Access Board explains that WCAG 2.0 is more explicit than the standards on Section 508 since the Success Criteria have been carefully created to be objective and testable, and the standards are technology neutral in order to apply to as many formats and resources as possible. Levels A and AA include a total of 38 Success Criteria. 22 of those are equivalents to the ones set in Section 508 (if one is successfully meeting Section 508 they would also be meeting those 22 on WCAG), but, since there have been some updates, it does not address 16 of them, showing a deficiency and need for development in these areas (US Access Board, 2017).

The documentation covered by Section 508 facilitates the understanding of the relationship between Section 508 and WCAG. The GSA Government provides a table (Table C.1, see Annex C) matching the Functional Performance Criteria (disabilities identified) of Section 508 with the Success Criteria of WCAG 2.0 in order to see the scope of each of the criteria and their impact (GSA Government, 2020b). This table can be found in Annex C complemented with the inclusion of the new Success Criteria for Mobile accessibility proposed in Chapter 4 as a result of this thesis.

It can be observed that two of the Functional Performance Criteria are not addressed by any Success Criteria: without speech and limited reach and strength. It should be noted, that WCAG is applicable to Web content and does not refer to the hardware and lack of speech is normally compensated by providing written inputs or other kinds of interactions, being a problem in the case of combining with other Functional Performance Criteria and most likely needing to be covered by level AAA.

2.2.4 INTERNATIONAL HARMONIZATION ATTEMPT

Since 2004 the EU has been cooperating with the United States aiming to harmonize the ICT accessibility standards under development to make Section 508 and the European regulation EN 301 549 consistent. Since both of them are directly referencing the WCAG the result has been two systems highly harmonized and compatible.

The use of harmonized standards would be beneficial for all the stakeholders. Fragmented standardization supposes that organizations with branches around the world would need to comply with different regulations depending on the country, elevating the resources needed and the cost of accessibility. It would also ease the generation of harmonized authoring tools that would increase the efficiency of content generation but allow the users to re-use the templates, evaluating tools and reducing training. In short, not only would it ensure the growth of the number of users that could benefit from accessibility without developing problems but also the efficiency of the resource generation which translates into economic saving (W3C - (WAI), 2011).

As explained in the previous subchapters, WCAG is considered the main reference for the generation and update of European and non-European regulations, which justifies the choice of WCAG as the centre of the analysis of this thesis.

Chapter 3:

Mobile accessibility

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Mobile accessibility

The term “Mobile” does not only cover Mobile phones but a larger range of devices such as tablets, smartwatches, wearables, household appliances, digital televisions, devices in cars and airplanes seatback and some others considered “Internet of Things” (W3C - (WAI), 2008).

Nowadays the use of smartphones does not only allow us to communicate but also to order food, buy any kind of things, provide information, track our health, a vast number of possibilities and resources that in the end provide us with a sense of safety. They have become a key factor in the performance of daily tasks and by being portable they give us the opportunity of using those resources almost in any situation. The different scenarios where we can use them bring with them some issues that should be taken into account when designing interactions and visuals to make sure that they are accessible for as many people as possible. As main differences between desktops computers or laptops and mobile devices we can highlight (W3C - (WAI), 2008):

- **Small screen size.** Mobile devices generally have a small screen size with a powerful resolution. The high resolution allows to render a great deal of information with good detail, but it entails the risk of

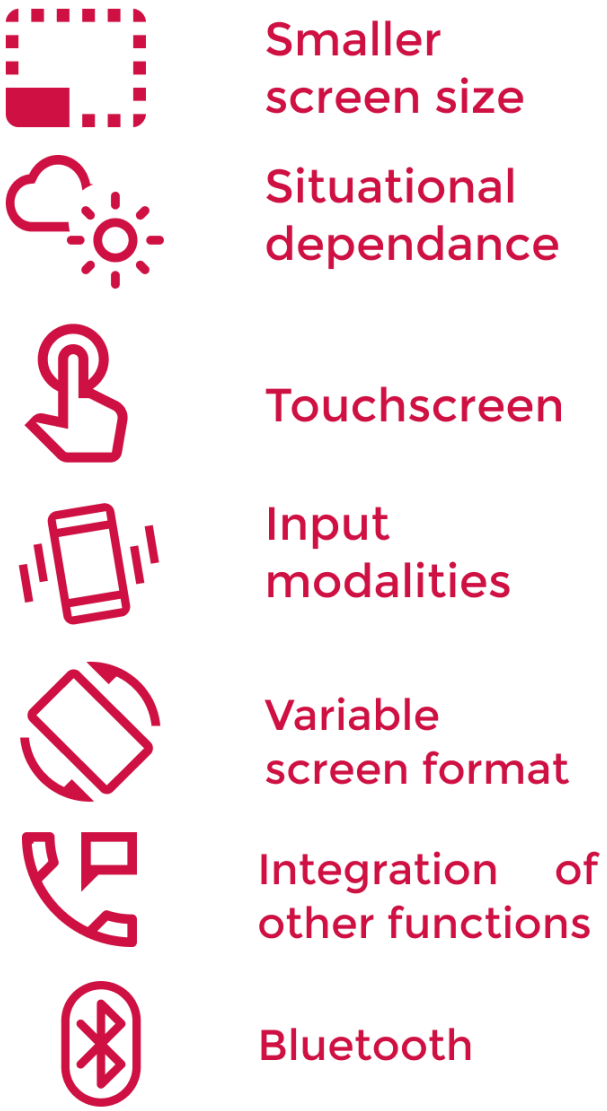

Figure 4. Summary of the defining characteristics of Mobile devices.

reducing the size of the elements for fitting more information, which can make it not readable or overwhelming. This entails the need of paying special attention to the responsiveness of the designs for adapting to different devices and of providing the user with some resources to make the information comfortably available such as zooms or magnifiers. In addition, it remarks on the importance of prioritizing the information structure to reduce the scrolling needed for finding substantial information.

- **Situational dependence.** In many circumstances we are using mobile devices on the outside, having interaction with different types of lights and environmental facts that can make visibility difficult. As an example, bright sunlight increases the need for contrast, raindrops can confuse the inputs on the touchscreen, or the movement of the train makes the selection of the buttons difficult. In addition, in these situations, the user may not have the full attention set on the process, enhancing the need for optimizing usability.

- **Touchscreen.** In general, mobile devices incorporate touch screens as the main way of interaction with the system. It brings, then, a change in the essence of interactions, switching from a cursor to gestures. This can bring some issues when it comes to precision of the interaction, range of motion and movement or pressure needed to perform the action. For some people, using a screen embedded keyboard is definitely more complicated than using an external physical one since it can include challenges derived from the small size of the tiles.

- **Different input modalities.** Mobile devices can include a big

number of sensors such as accelerometers, gyroscopes or pressure sensors that provide new opportunities for interactions leveraging on the ease of handling of the devices.

- **Variable screen format.** Users have the choice to decide if they want to visualize the information in portrait mode or landscape, which variates the distribution of the elements and engages in the need for responsiveness.
- **Integration of other functions.** Designing for mobile devices presents the advantage of having access to the other functions of the device and creating interactions between them for improving the user experience (e.g., selecting a contact number of the app and directly having the option of calling with the phone) (Enginess, 2016).
- **Bluetooth.** The inclusion of Bluetooth, a wireless short-range interconnection device of electronic (Oxford Languages, 2021), in mobile devices allows the user to benefit from s great number of assistive technologies connected such as switches, keyboards, etc. This allows the user to have alternative controls of the system (Wandke, 2017). Bluetooth is normally also included in desktop devices. However, its implementation on mobile devices provides the user with a wide range of options for improving accessibility on the way compared to the ones useful in desktop devices. In consequence, we can consider Bluetooth as a characteristic of mobile devices impacting accessibility (Byrne Haber, see Annex A).

When it comes to Mobile Accessibility, we need to take into account that there are factors that cannot be controlled by the interaction or interface designer. A great part of the impact will rely on the Operational System of the device using integrated accessibility features such as screen readers. This dependence on the Operating System can be considered as closed functionality. It then raises the question of if close functionality should be considered as a characteristic of mobile devices (Moledo, see Annex A). Withal, the functionalities and accessibility options integrated by the Operating System are very variable. Apple remains very consistent while for Android devices there is a great number of companies involved (Google, Nokia, Samsung, etc.) that generate a more inconsistent structure on the accessibility options provided in their devices. Consequently, it is not recommendable to generalize close functionality as one of the

characteristics of mobile devices since their flexibility depends on the companies (Byrne Haber, see Annex A). The hardware, size, shape, weight, components, materials, etc. will have important consequences on the accessibility of the product. Right now, the market is mainly covered by three Operating Systems iOs (designed by Apple), Android (designed by Google) and Windows (designed by Microsoft which is not that popular in smartphones as it is in tablets). In 2021 the global market shares of iOs and Android represented 98% of the total (Statcounter, 2021).

Each of them has bet on improving the accessibility of their products by paying special attention to specific products which rather than separate became a part of the operating system's options.

Apple

Apple provides built-in features for accessibility related to the following difficulties:

- **Vision.** VoiceOver as a screen reader, braille, text magnifier, spoken to text, zoom, audio description, shortcuts, dark mode, text size adaptation, reduce motion and the assistant Siri (Apple Inc, 2021c).
- **Mobility.** Including voice control, switch control (moving by tabbing), assisting touch, touch accommodations, back tap (for opening main apps), accessibility keyboard, keyboard connection, dictation, predictive text, and activity and workout inclusive apps with wheelchair mode (Apple Inc, 2021b).
- **Hearing.** Sound recognition, headphones accommodation, life listening, sensory alerts, mono audio, facetime, real-time text, type to Siri, scribble (drawing letters) or closed captions (Apple Inc, 2021a).
- **Cognitive.** Spoken content, Safari reader, guided access, hover text, dictation, predictive text and screen time control (Apple Inc, 2021a).

Their approach is based on the defence of two principles that entail similarities with the ones presented by WCAG: Simplicity, referring to "Enabling familiar, consistent interactions that make complex tasks

simple and straightforward to perform." and Perceivability ``Making sure that all content can be perceived whether people are using sight, hearing, or touch." (Apple Inc, 2021e). In fact, they have recently developed new features to promote accessibility such as assistive touch for not needing to interact with the touchscreens leveraging on internal sensors to identify the interaction, or the inclusion of alternative interaction customizable gestures such as back-tap or relying on third parties for allowing navigation through eye-tracking. They have also developed SignTime, a service of real-time translation to sign language for communicating with Apple Care and Customer Service retail. Background sounds help to keep the user focused on the main interaction and VoiceOver is now able to analyse pictures more in-depth to describe them for vision impeded users (Apple Inc, 2021d).

Google

Google on Android offers similar tools to improve the accessibility of its products (Google, 2021):

- **Vision.** TalkBack as a screen reader, zoom, contrast and text size options, BrailleBack, Lookout (artificial vision system to help to interact with the environment).
- **Interaction.** Voice access, switch controls, action blocks (to complete everyday tasks from the main screen of your device), action time regulation (for setting how long should the messages appear on the screen).
- **Audition.** Personalized and automatic subtitles, on the moment transcription, text translation of the sound notifications, sound amplifier, compatibility with hearing aids and real-time text during calls.

Microsoft

Microsoft divides their accessibility options into six categories and includes these accessibility tools (Microsoft, 2021):

- **Vision.** Colour filters for adapting the perception of the screen, Screen Narrator and Cortana, screen magnifier, on-screen keyboard,

"Tell Me" for finding commands without navigating, sticky keys and filter keys.

- **Hearing.** Automatic subtitles, on the moment transcriptions, sound notifications, sound adjustments and notifications adjustments.
- **Neurodiversity.** "Tells Me" for finding commands without navigating, Focus assistant to block the notifications, easy to read fonts, personalization of controls' position and reading mode for displaying only the content to be read, hiding all the information that can be distractive.
- **Learning.** Grammar and spelling checker, suggestions on writing and wording, adjusting the space between words and lines, reading the text out loud, separating it in syllables and identifying grammar categories.
- **Mobility.** Writing by using your voice, keyboard accessibility features biometric authentication, speech control and compatibility with eye-tracking control.
- **Mental health.** OneNote and tasks management features focus mode, personalize visualization mode and provide feedback on the working habits based on the use of the applications.

Generally, apart from the features included in the Operating System, they also develop complementary Apps and assistive technologies for improving accessibility. In addition, all of them include accessibility guidelines and resources as part of their design systems: Apple's Design system, Material Design for Google or Fluent Design for Microsoft.

3.1 WCAG and Mobile accessibility

When it comes to Mobile accessibility WCAG does not present any different guidelines but strongly defends the application of the general guidelines already set to Mobile devices. They believe that there are a great number of similarities between them and desktop or laptop devices. Regarding interaction, many desktops or laptops include touch screens as a way of control and generally mobile devices can be connected to external hardware for controlling such as mouses and keyboards. The programming of the webpages as responsive sites allows the user to visualize the same information more comfortably adapting to the different screen sizes and laptop/desktops can also include mobile operating systems. In addition, the majority of the elements and components are commonly used in both types of devices and present consistencies in the behaviour and appearance (for instance buttons, links, carousels, cards, etc.), being directly applicable to the already existing WCAG (Patch, Spellman and Wahlbin, 2015).

The draft of EN 301 549 V3.1.1Annex A Table A.2 the existing requirements that can be related to mobile content and applications (ETSI, 2019). WAI addresses the application of WCAG 2.0 to Mobile devices directly highlighting the most relevant aspects and the guidelines they are directly related to, providing informational guidance on their application rather than establishing requirements (Patch, Spellman and Wahlbin, 2015). The information contained in this document is a combination of the Best practices for Mobile web accessibility provided by WAI (Rabin and McCathieNevile, 2008) and the WCAG 2.0 they are related with. The document exposes the main issues on Mobile devices we have already mentioned organized according to the four principles and enumerates the relevant success criteria. The following information is a representation of the content of the document “How WCAG 2.0 and Other W3C/WAI Guidelines Apply to Mobile” published by W3C in 2015.

3.1.1 PERCEIVABLE

The perceivable principle is affected by the small screen size, the zooming options and the contrast needed. To deal with the small screen size they

recommend the minimization of the information rendered and the generation of responsive design for the content, rethinking the information needed and ensuring the correct visualization in different screen sizes. The target size for the controls and the length of the texts should also be adapted. When it comes to forms, they recommend placing the input fields under the labels and not next to them to facilitate the visualization and promote consistency.

Regarding the display of the text in larger sizes we can find different options, Operating Systems, for instance, iOs, Android and Windows, normally provide the option for resizing the text, scaling it according to the structure programmatically set. In addition, they provide other options such as magnifying the full screen or a lens effect to magnify the space under the user's touching finger without needing to use additional assistive technologies. Alternatively, browsers can also provide the option of enlarging the text in the viewport or magnifying the screen (normally by "pinching-zooming"). At this point, success criterion 1.4.4 Resize text (Level AA) appears, establishing a need of enlarging up to 200% without using any assistive technology and recommending methods to achieve it. However, as we will explain in further subchapters, some other guidelines are also highly relevant and related for the correct alleviation of this issue.

The third consideration for the screen is the colour contrast. This factor is also related to the identified issue of situational dependence, and it is especially relevant when the devices are used outdoors since the glare of the sun might provoke difficulties for the correct visualization of elements with poor contrast. The paper presents two success criteria for the issue: 1.4.3 Contrast (Minimum) (Level AA) and 1.4.6 Contrast (Enhanced) (Level AAA) explaining also that people with vision problems might benefit from the combination of these aspects with some of the already mentioned such as zooming or resizing the text. Once again, we could find more success criteria that can contribute with contrast and should be taken into consideration, for instance, success criterion 1.4.11 Non-text contrast (Level AA).

(Patch, Spellman and Wahlbin, 2015).

3.1.2 OPERABLE

The main difference between Mobile and Desktop devices in terms of interaction is normally that Mobile devices are mainly controlled by touch screens while desktop ones use a keyboard and cursor.

People with disabilities often need to rely on external physical keyboard control for their devices so making them available and controllable by keyboard is a need. Physical keyboards have separated keys and more predictable layouts and can be adapted to special needs such as braille keyboards for vision-impaired people. People who suffer from dexterity or mobility problems can also benefit from the use of adapted solutions that help to overcome the issues. In general, having a physical keyboard can provoke a sense of consistency and self-confidence. WCAG 2.1 applied to mobile enumerates four applicable success criteria: 2.1.1 Keyboard (Level A), 2.1.2 No Keyboard Trap (Level A), 2.4.3 Focus Order (Level A) and 2.4.7 Focus Visible (Level AA).

In order to prevent errors and ease the interactions the size and distance of the target elements should be enough. Rather than directly relating the issue with a success criterion (target size success criterion 2.5.5 is level AAA), in this case, it relies on the best practices document provided (which will be discussed after the following) emphasising that the size is absolute and not relative; in other words, it is not dependant on the screen resolution.

The interaction with a touchscreen can rely on a range of gestures and movements that can variate the direction, pressure and level of complexity and difficulty. Once more, we can appreciate best practices such as easing and simplifying the movements, avoiding multi-touch gestures and focusing on tapping and swapping. In addition, attention during the programming phase is needed to guarantee the correct trigger of the actions based on states and interactions, avoiding unintentional actions and providing flexibility. In addition, leveraging on consistent gestures can make the interaction with the product more intuitive and easier to learn.

Some Mobile devices include different gestures that even when not requiring the interaction with the touchscreen can trigger new actions

(e.g., shaking the smartphone). The actions that are triggered these ways should also be accessible by the use of keyboards, as it is exposed on success criterion 2.1.1 Keyboard (Level A).

Finally, it addressed the need of placing the buttons in easy-to-reach positions and avoiding the need of using two hands.

Despite the importance of keyboards and touchscreens as an interaction agent, we should take into account the rise of new technologies in the market and their impact on control and interactions, for instance, Speech control or eye-tracking, which would be interesting to consider in relation to their operability and availability. In general, the consideration of further input modalities and associated success criteria should be studied and could be considered in future versions of WCAG.

(Patch, Spellman and Wahlbin, 2015).

3.1.3 UNDERSTANDABLE

One of the issues of Mobile devices is the need for flexibility in terms of orientation, being beneficial to adapt the information to portrait or landscape visualization to improve the experience on fixed devices such as the display of an electric wheelchair. In order to achieve this, the layout of the design needs to be consistent, adapting the components to the current layout and ensuring access to all the navigational components. Consistency between the different screen sizes and screen orientations is not a requirement under WCAG 2.0, which is reflected on the success criteria 3.2.3 Consistent Navigation (Level AA) and 3.2.4 Consistent Identification (Level AA).

Both factors are connected to the need for a hierarchical structure of the information enabling the visualization of the most relevant information without scrolling. The consistency and predictability of the most important elements can be especially beneficial for people with low vision or cognitive impairments, helping them to recognize them rather than needing to remember and discover them.

Elements and components that perform the same actions should be grouped. By doing it, the target size is increased, and it is easier for users with dexterity problems to interact. Success criteria 2.4.4 Link Purpose (In Context) (Level A) and 2.4.9 Link Purpose (Link Only) (Level AA) are applicable to the topic, clearly stating the result of the interaction.

In addition, those elements that are actionable should be clearly indicated and distinguishable from non-actionable elements. Not only should they be identified visually but also from a programming point of view to ensure the identification by users using a screen reader, speech controlling or other assistive technologies. Visually speaking, design systems often offer clear examples and guidelines to follow to make these elements recognizable based on popular standards and consistency. Once again success criteria 3.2.3 Consistent Navigation (Level AA) and 3.2.4 Consistent Identification (Level AA) are mentioned.

Finally, to give the user control of the interaction they recommend providing instructions for customizing the gestures for the touchscreen and the manipulation ones. Since they can be difficult to discover it is interesting to include instructions for them and make them easily available. The concept introduces success criteria 3.3.2 Labels or Instructions (Level A) and 3.3.5 Help (Level AAA).

(Patch, Spellman and Wahlbin, 2015).

3.1.4 ROBUST

The robust principle does not include any of the WCAG 2.0 guidelines but three proposals on how to facilitate the data entry and input. It recommends the programming of the keyboard for being automatically set to match the input type for data entry. This action can improve error prevention and could be related to the resulting Success Criterion.

Data entry should also be simplified by providing multiple ways to insert it and reducing the amount of text needing to be inserted by using checkboxes or reusing data already entered.

Finally, it highlights the need of making the web apps compatible with the different assistive technologies provided by the Operating Systems or externally implemented.

(Patch, Spellman and Wahlbin, 2015).

3.1.5 OTHER USEFUL DOCUMENTS

Some of the best practices and issues mentioned in the document are directly related to success criteria but not necessarily mentioned if they are, for instance, identified as Level AAA. As we have already mentioned, WAI also published a document in 2010 named "Mobile Web Application Best Practices" that was used as a reference for the just explored "How WCAG 2.0 and Other W3C/WAI Guidelines Apply to Mobile".

The best practices aim to prevent harmful practices and encourage the use of accessible and dynamic web mobile applications. It includes a total of 32 best practices written from an engineering point of view to bring a good experience for a great range of mobile devices. The main topics referred to are: Application Data, Security and privacy, User Awareness and Control, Conservative use of resources, User Experience, Handling Variation in the Delivery Context and other Further Considerations. However, these best practices have been developed highly focussed on programming. Nevertheless, they include relevant information in the field of design that will be taken into account in the main analysis performed in this project (Connors and Sullivan, 2010).

In addition, WAI provides the "Guidance on Applying WCAG 2.0 to Non-Web Information and Communications Technologies" (WCAG2ICT) a non-normative and not requirements-based guide on how to apply WCAG 2.0 to the non-web sector, paying specific attention to non-web documents and software. This refers to the services provided by external software, operating systems, user agents (including assistive technologies and the features provided by the operating systems) and therefore it is related to native Apps. The document basically screens the success criteria of version 2.0 citing the original source and remarking the adaptations needed to be performed. Out of the 38 success criteria that correspond

to levels A and AA in version 2.0 26 of them can directly be applied since they do not use any web-related terms. The remaining 12 only needed some light arrangements such as the substitution of “web-page” or similar related terms with non-web ones such as “non-web document” or “software. Four out of these twelve include some differences in terms of the unit of evaluation. WCAG 2.0 is established as a “unit of conformance” “multiple web pages” or a “set of web pages” but these terms are not directly applicable for non-web content since the terms “set of documents” or “set of software” do not represent the concepts behind. As a compromise, the guidelines include the term “unit of evaluation” for a more abstract but conformant representation (Korn et al., 2013). Since WCAG2ICT does not consider the interaction with hardware or situational factors the guidelines to be applied are basically the same as on WCAG 2.0. We should remark that the document was published in 2013 and, therefore, it does not work on the most updated state of the guidelines and some of the success criteria are missing.

Chapter 4:

Proposal of new Success Criteria for Mobile accessibility

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Proposal of new Success Criteria for Mobile accessibility

As we have already mentioned, WCAG suggests the direct application of WCAG 2.1 to the design for Mobile Devices. However, some of the differences between desktop and mobile devices previously exposed require further attention and raise the possibility of establishing new success criteria to define them. The following table (Table 1) presents the five different potential success criteria that have been identified:

Principle, Guideline and Criteria	Level proposed	Functional categories
Perceivable. Guideline Distinguishable		
1.4.A Enable Dark mode	AA	Vision and visual
1.4.B Minimum font size	AA	Vision and visual
1.4.C Minimum image resolution	AA	Vision and visual
Operable. Guideline Input modalities		
2.5.A Enable Speech input	AA	Mobility / Motor
Operable. Guideline Keyboard accessible		
2.1.A Alternative to Biometric Authentication	AA	Executive

Table 1. Potential success criteria identified

The next subchapters explain in detail the justification found for each of the potential success criteria proposed and present their intention, benefits and recommendation for the implementation (as an alternative to sufficient techniques) following the structure set by WCAG 2.1. After explaining the Criteria, the validation chapter summarizes the feedback and contributions given by experts in the field.

4.1 Success criteria proposed

4.1.1 Success criterion 1.4.A Enable Dark mode (Level AA)

Justification

Dark mode, also known as "Dark theme", "night mode" or "light-on-dark" is a concept of UI design based on the inversion of contrast polarity. Contrast polarity describes the contrast between the text and the background. We are generally used to visualize Mobile Apps on positive contrast polarity (light mode) which presents dark text on a light background (Figure 5). On the other hand, it is getting more and more common to visualize UIs that leverage Negative contrast polarity (dark mode) which displays light text on a dark background.

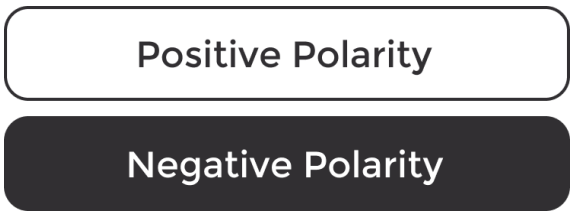

Figure 5. Example of positive and negative polarity.

Even though Dark mode can be understood as an innovation in the UI design field, it was the original display mode since computers and TV screens used to present the information due to the capabilities of the cathodic-ray tubes that formed them. The aim for resembling paper documents and their general style led to the change towards Positive contrast polarity(Lunn, 2021).

The main idea behind the reintroduction of the Dark mode into the UI trends is the reduction of the light emitted, justified by the long exposure times of users to the screens and to the aim of saving energy and

prolonging the duration of the batteries, without affecting the readability and preserving the contrast ratio (Lunn, 2021).

One of the benefits attributed to Dark mode is the reduction of exposure to blue light. Blue light describes the frequency of the light emitted by screens that relate to daylight. By reproducing the daylight frequency, it can make one feel more active since it prevents the production of melatonin (the hormone that encourages sleeping) and produces disorders in the circadian rhythm, preventing people from falling asleep after interacting with screens and supposedly being beneficial during the nights. Some studies defend the power of dark mode for reducing eye strain, dried eyes and sight tiredness when using it in places with low lighting levels since it should be easier for your eyes to adapt the aperture of the pupil for looking at the screen in a poorly illuminated atmosphere, in other words, avoiding screen glare (Laderer, 2021). In addition, it can minimize the disturbance produced to other people around when the device is used in a dark ambience, help to reduce the battery consumption in case of emitting through an OLED or AMOLED screen since they use true black by turning the pixels off and minimize possible flickering issues.

However, the investigation of these impacts needs to be developed in further detail Some studies, fight against the benefits of Dark Mode on the health of the eyes exposing that the impact of the screen light is not enough for having a relevant influence on the secretion of melatonin (Nagare et al., 2019). In any case, some mobile devices already provide an alternative to Dark mode for tackling blue light emission that can easily be set. When it comes to reducing eye strain and dryness there are also studies that suggest it might not reduce glare and tiredness since users who suffer from astigmatism will be affected by the halo effect that the eye will try to correct. Halation means the perception of the content is slightly blurred due to the scattering and reflection of light inside the eye (Locke, 2020).

Reading long texts in dark mode can be challenging, and so can the use of dark mode in ambience highly illuminated (Lunn, 2021). And in general, dark mode seems to have a negative in readability for users with normal vision (or corrected by the use of contact lenses or glasses) and it is difficult to perceive in very bright ambiences.

It raises, then, the question of the need for the existence of Dark mode and its proposal to be exposed as a possible inclusion on the WCAG adapted to Mobile devices.

The response to this question and justification of the importance of the inclusion of Dark mode is included in the study performed by Legge and more, which concluded that people who suffered from a kind of low-vision impairment, Cloudy ocular media, were strongly benefited from the use of Dark mode for reading(Gary et al., 1985), even though it has lower readability rates for people without visual impairments. This statement is also sustained by Papadopoulos and Goudiras in their study "Accessibility Assistance for Visually Impaired People in Digital Texts" (Papadopoulos & Goudiras, 2005). Figure 6 is a simulation of the visualization of the same UI (Display and brightness settings for iPhone) by a person suffering from cataracts, a common type of Cloudy Ocular Media, that illustrates the benefits of the perception of Dark mode (the simulation was performed using SEE disability simulator). Another study performed in 2018 by Nature Research's Scientific Reports (Aleman et al., 2018)shows that, in the long-term, reading on Light mode might be linked to the development or worsening of myopia (failure to see clearly objects in the distance).

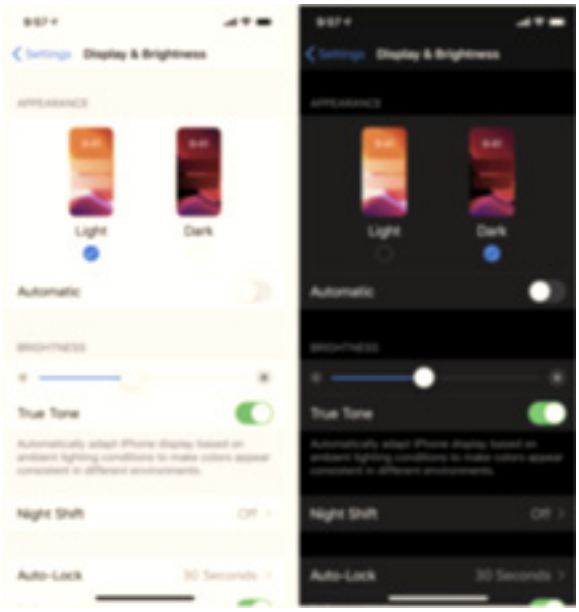

Figure 6. Simulation of the visualization of Light and Dark UI by a user with cataracts.

In addition, it also results beneficial for the interpretation and visualization of charts or graphics since it "allows the content to stand out" (Apple Inc., 2021b). Some famous apps such as Spotify that counts 356 million users have bet on using the Dark mode as the default setting for their apps. In the same way Netflix, Amazon Prime, Amazon Music, Movistar plus, Adobe set to leverage Dark mode as the default setting in order to enhance the perception of their content and reduce glare since they are likely to be used in dark atmospheres.

As Raluca Budiu explains on behalf of the Nielsen Norman Group (reference on User-Experience) (Budiu, 2020)the best choice is to provide the users with both of the options, Light and Dark Mode, and allow them

to take the decision according to their own needs and toughs; benefiting those users with vision impairments or photosensitivity, those who want to prevent possible myopia issues and those who simply like it or believe that works better them.

For the implementation of Dark Mode, the main Design Systems recommend using dynamic colour systems that are able to adapt the primary, secondary and tertiary colour to the new visualization mode and still comply with WCAG contrast regulation. Google suggests the use of tone 200 to do it (Figure 7). The Design System UniCredit Omnichannel chooses tone 600 for "inverted" colours (Figure 8), which, even though they comply with the contrast requirements they take a lot of protagonism and create the risk of overdoing the Dark Mode UI (Google Design, 2021a).

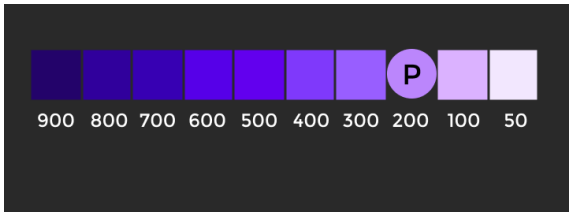

Figure 7. Example of tone 200 on Google Design system (2021a).

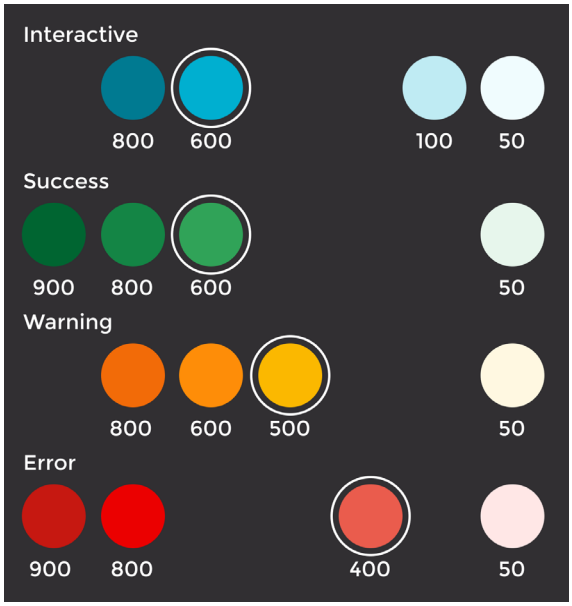

Figure 8. Dark mode colours proposed in UniCredit's Omnichannel design system.

Now that we have explored the impact of the Dark mode and justify its inclusion of the proposal for necessary WCAG guidelines applied to Mobile Devices we present the proposed criteria addressing it.

Principle Perceivable.Guideline Distinguishable.

SC 1.4.A Enable Dark mode (Level AA)

"Dark mode is enabled for the necessary platforms and fulfils the contrast requirements for text and non/text content."

Intent

This Criterion provides an alternative UI visualization that reduces the amount of light by relying on negative contrast polarity (light text on dark background). The intent of this success criterion is to ease the perception of the UI for people who are affected by photophobic conditions or suffer from some types of visual impairment such as Cloudy Ocular Media.

The continuous use of positive contrast polarity (light mode) is associated with the development of myopia and some users prefer to set the dark mode for specific occasions in order to reduce the impact on the ambience and avoid disturbing other people around, for instance, being in the cinema.

By providing both UI, positive contrast polarity based, and negative contrast polarity based, the user has the option to choose the one that adapts better to his/her visual needs and improve the accessibility for some visually impaired users.

Benefits

- Photophobic users stand better the reduced amount of light coming from the screen
- Users with Cloudy Ocular Media have a better perception
- Enhance the perception of charts
- Reduce possible risks of developing myopia due to long term use

Recommendations for implementation

Summary:

- Allow dark mode respecting the system preferences
- Test the UI in both, light and dark mode
- Preserve the predominance of dark ambience
- Reduce the use of colours and leverage on dynamic colour systems
- Ensure contrast ratios in all layers
- Use desaturated light colours
- Adapt icons, symbols, glyphs and images using asset catalogues

The last versions of the most famous Operating System offer Dark Mode as a possible default interface style for displaying the information giving even the option to schedule them. In order to provide a smooth transition of the interfaces of the apps to this style, the designers and developers need to allow the app to embrace the system preferences and respect them.

A document created using default colour for the text and default for the background can easily be adapted to dark mode if the user chooses it, by using its default colour, but if you are setting the text colour to green you are forcing the user to visualize it that way. In the same way, if the background colour of the app is set as default the system will adapt it to the new requirements (Scano, see Annex A).

Apart from using default modes for the design, the interface should always be tested in both modes to make sure that the contrast between the elements is correct and the interface can be correctly visualized. Not all the designs work correctly in both modes. Pay attention to legibility and ease of reading, especially in the case of having backgrounds affected by transparency. Contrast requirements specified in success criteria 1.4.3 Contrast (Minimum) and 1.4.11 Non-text contrast should be respected. In addition, images need to be chosen or adapted to fit in both contexts by using assets catalogues.

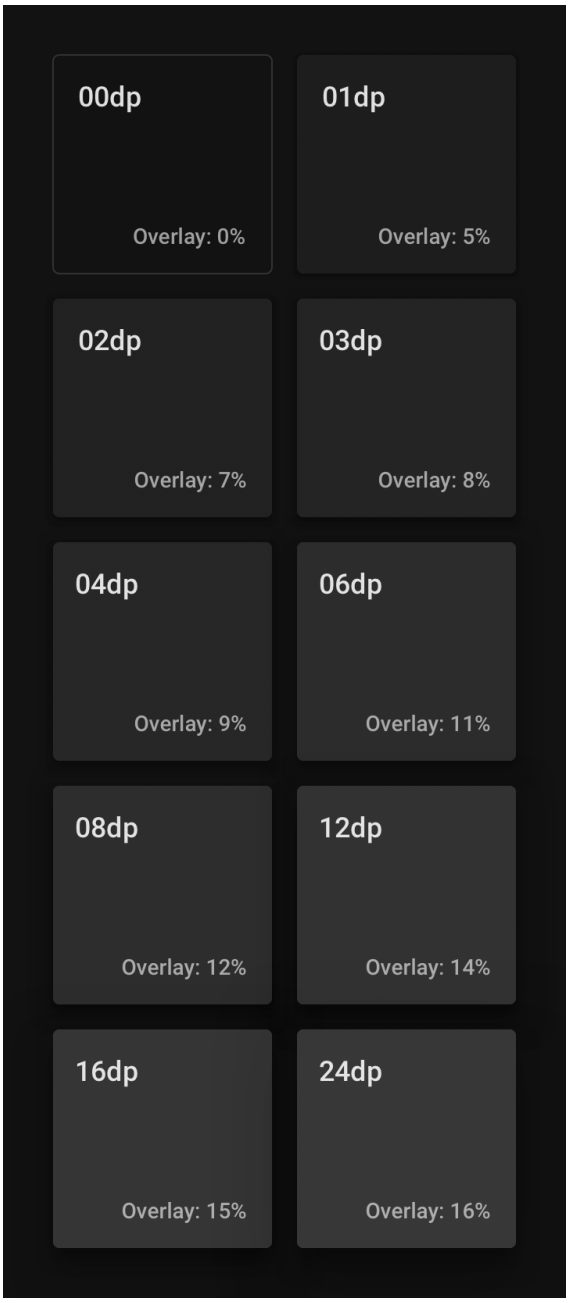

Figure 9. Definition of transparency layers on dark mode on Google Design (Google Design, 2021a).

Colours:

The dark mode is characterized by using darker background colours and lighter foregrounds. Google guidelines defend the use of dark grey rather than black as a background colour to have a wider range for creating elevations by applying layers of slightly lighter colours on top of each other and enhance the perception of depth. These lighting layers that make the elements feel closer to the user are created by applying transparency layers on top of the components using On Surface Colours (see Figure 9) (Google Design, 2021a).

Colour contrast should be compliant in all the elevation layers. Google Material states that in order to preserve the legibility on the highest and lightest surfaces and comply with success criterion 1.4.3 Contrast (Minimum) level AA (4.5:1) the contrast between text and the darkest background colour needs to be 15.8:1. (Google Design, 2021a).

When using colours, it is recommended to add colours set to the assets and components to make them dynamic and define the different variations (dark and light mode) depending on the mode instead of using hard-coded colour values (Apple Inc., 2021f).

In case of needing to use white colour, rather than using pure white it should darken a bit to emit less light. Saturated colours do not comply with the regulation on Dark Mode and they can produce eye strain. It is better to reduce the use of the Accent colour as much as possible to preserve the general darkness and use desaturated colours for improving the contrast, and it should be light and desaturated (Google Design, 2021a).

As mentioned, the use of dynamic colour systems eases the transition to

dark mode. Colour systems normally define three main colours: primary, the one that will be used more frequently, secondary, for grouping content or accent the main parts and tertiary, for grouping secondary elements (Apple Inc., 2021g). To ensure the compliance of the primary colour with WCAG requirements Google Materials proposes the use of 200 tone of the primary and secondary colour as illustrated in Figure 7 (Google Design, 2021a).

Icons and symbols should also use dynamic colour systems and colour sets rather than hard-coded ones to adapt correctly. In the case of using glyphs, it might be interesting to think about changing their appearance from outlined in light mode to solid in the dark one (Apple Inc., 2021f).

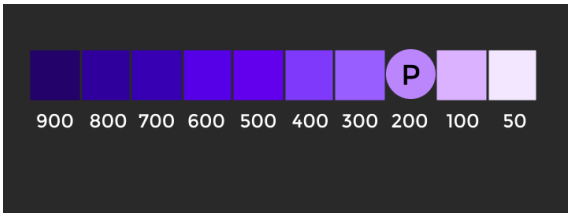

Figure 7. Example of tone 200 on Google Design system (2021a).

4.1.2 Success criterion 1.4.B Minimum font size (Level AA)

Justification

When it comes to text guidelines WCAG presents, among others, success criteria for defining the need for allowing resizing (success criterion 1.4.4 Resize text) and reflow (success criterion 1.4.10 Reflow), managing the text spacing (success criterion 1.4.12 Text spacing), ensuring the transcription of the information contained in images of text (success criterion 1.4.5 Images of text) and the text contrast for ensuring visualization (success criterion 1.4.3 Contrast - Minimum). Some of these success criteria are stated as a function of the font size and establish different dependent variables. success criterion 1.4.12 Text Spacing (Level AA) requires the adaptability of the text content when changing styles such as the line height, the space between paragraphs, the letter-spacing (tracking) or the word spacing, using as a unit the font size and determining the variation as a function of it. However, there are no specific success criteria for addressing and defining the minimum font size recommended.
success criteria 1.4.3 Contrast (Minimum) (Level AA) divides the

requirements for textual contrast into two groups attending the scale of the text. For general text, the minimum contrast is 4.5:1, while for large scale text it is enough to have a 3:1 contrast ratio. The glossary included as part of the WCAG 2.1 defines Large Scale text as that "with at least 18 points or 14 points bold or font size that would yield equivalent size for Chinese, Japanese and Korean (CJK) fonts" (W3C - WAI, 2018)clarifying that this statement is evaluated before applying any kind of resizing or feature change by the user and can variate in case of having a font with unusual features or made out of very thin strokes. Text over 18 points is then considered large by WCAG.

Text size can be measured using statics units or relative ones. The most frequent statics measures are CSS pixels and points. 1 CSS pixel [px] is equivalent to 0.75 points [pt]. 1 px corresponds to 1/96 inches, when we are working on low-resolution devices then one px might be equivalent to one device pixel (one dot on the screen), while, if working on high-resolution devices on px will correspond to several screen pixels (W3 schools, 2021). Alternatively, relative units are set depending on another variable. For instance, percentage representations refer to the parent element and "em" to the size of the font in relation to the default font size for the body, which generally corresponds to 16px. In some cases, the final size for the text can depend on both, the one set by the author and the settings of the user's display or agent and they are automatically adapted to the size of the display (for instance, when the user chooses to resize the text on the device configuration). W3C recommends the use of relative measures to improve the adaptability and responsiveness of the UI to different devices and leave absolute units such as pt for printing purposes (W3C, 2021). Since the screen of a mobile phone is remarkably smaller than the one of a desktop, the same font size might be perceived as large on the mobile phone's screen and small on the desktop. In addition, the legibility of the text will also be determined by the style of the font used and the colour contrast between the text and the background.

The recommendations provided by the main Operative Systems are stated according to the font that characterizes their design systems. This means that limiting the minimum allowed font size does not guarantee legibility since it depends on more factors, but it supports the correct result of the application of other already mentioned success criteria such as 1.4.10 Reflow or 1.4.4 Resize text.

As we have already mentioned, the term “Mobile devices” includes a vast number of devices that can have different screen formats and resolutions, in general, smaller than desktops. In some of these devices such as smartwatches, the size of the display is very small. The definition of a minimum font size would help developers and designers to set the limits of the design and generate more usable interfaces. In addition, resizing the text on a Mobile device normally means increasing the need to scroll on the page to visualize all the information. By setting a minimum text size we can minimize the need for resizing for users without visual impairments.

Despite including all that information, WCAG does not present a specific success criterion for defining the minimum font size recommended before resizing, generating the motivation to be analyzed and proposed. Roberto Scano, one of the experts interviewed, states that there is a lot of controversy about whether the minimum text size is to be defined, explaining the idea used behind the conception of the mentioned success criterion was that developers should set a baseline font size at 1em (see Annex A).

Definition of minimum text size.

The main Operating Systems set on their Design System resources the font sizes corresponding to each part of the structure where text is needed. These specifications are determined according to the specific fonts chosen for the design system. Consequently, there might be the possibility that even though the font size guideline is followed the text will not be completely legible, since it depends on the design of the font itself and the colour. As Byrne Haber explained in the interview (see Annex A), sans serif fonts are easier to read than serif fonts so the minimum font size might even be different depending on the type of font. Nevertheless, the respect of the minimum size supports the correct implementation of other success criteria previously mentioned.

The idea behind the use of a relative unit such as “em” is not setting the size of the body but relying on the default size set in the device as a reference. In this way, if the user changes the configuration of the device for resizing the text all the elements will be scaled according to it. W3C sets as default font size for the body 16px being 16px = 1em. However, in

the case of small devices, the default font for the body may be adapted for being able to display more information on the screen. Even though W3C recommends the use of relative units such as “px” or “em”, most of the design programmes use “pt” as a unit for font size (W3C, 2021).

Table 2 displays the information of font size structure developed by the main Operating Systems analyzed and the structure provided by W3C in HTML coding. Google uses “sp” as a general unit for font size, being equivalent to “px”, while Apple and Microsoft prefer to use “pt”. Some of the structural elements presented have different names or are not directly addressed by one of the Design Systems, in that case, it has been indicated using a dash.

Apple.
(Apple Developer, 2021)
Taking as reference the default (large) option. Point size based on image resolution of 144ppi for @2x and 216ppi for @3x designs.

Google.
(Material Design Google, 2021)
Web browsers calculate the REM (the root em size) based on the root element size. The default for modern web browsers is 16px, so the conversion is SP_SIZE/16 = rem. Conversion ratio px - sp - pt is 1:1

Microsoft.
(Microsoft, 2021)

W3C.
(W3C, 2021)

Style	Apple		Google		Microsoft		W3C	
	pt	px	pt	px	pt	px	pt	px
H1	-	-	75	96	51	68	24	32
H2	-	-	45	60	-	-	18	24
H3	-	-	36	48	-	-	14	18.72
H4	34	45.3	25.5	34	30	40	12	16
H5	28	37.3	18	24	21	28	10	13.28
H6	22	29.3	15	20	-	-	8	10.72
Subtitle 1	17	22.7	12	16	15	20	-	-
Subtitle 2	-	-	10.5	14	13.5	18	-	-
Body 1	16	21.3	12	16	10.5	14	12	16
Body 2	-	-	10.5	14	10.5	14	-	-
Call out	16	21.3	-	-	-	-	-	-
Footnote	13	17.3	-	-	-	-	-	-
Button	-	-	10.5	14	-	-	-	-
Caption 1	12	16	9	12	9	12	-	-
Caption 2	11	14.7	-	-	-	-	-	-
Overlines	-	-	7.5	10	-	-	-	-

Table 2. Comparison of font size systems on [pt] and [px].

On the other hand, Table 3 displays the equivalent font sizes in "em" units, taking as a reference that 16px correspond to 1em (W3 schools, 2021).

Style	Apple	Google	Microsoft	W3C
	em	em	em	em
H1	-	6	4.25	2
H2	-	3.75	-	1.5
H3	-	3	-	1.17
H4	2.83	2.13	2.5	1
H5	2.33	1.5	1.75	0.83
H6	1.83	1.25	-	0.67
Subtitle 1	1.42	1	1.25	-
Subtitle 2	-	0.88	1.13	-
Body 1	1.33	1	0.88	1
Body 2	-	0.88	0.88	-
Call out	1.33	-	-	-
Footnote	1.08	-	-	-
Button	-	0.88	-	-
Caption 1	1	0.75	0.75	-
Caption 2	0.92	-	-	-
Overlines	-	0.62	-	-

Table 3. Comparison of font size systems on [em].

Apple.
(Apple Developer, 2021)

Google.
(Material Design Google, 2021)

Microsoft.
(Microsoft, 2021)

W3C.
(W3C, 2021)

The minimum size presented by Apple in their Design System is 11pt, the value assigned to Captions (Apple Inc., 2021h). Even if we check the configuration for smaller text, for the implementation on small devices such as smartwatches, the lower limit of the font size is 11pt.

Google uses a minimum font size of 10px, 7.5pt when writing the Overlines (Google Design, 2021b). From its side, Microsoft uses a minimum of 9pt for Captions (Microsoft, 2020). Other ergonomic studies focused on ensuring the legibility of the text such as the one performed by Jörg Fuchs in 2010 under the title of "New font size requirements in package inserts of medicines" determine a minimum font size of 9pt as minimum font size for ensuring visibility of the majority of people (Fuchs, 2010).

Given the premises mentioned and taking into account the required possibility of resizing the text to comply with WCAG 2.1 we can take as valid the lowest minimum font size proposed by Microsoft, which corresponds to an absolute size of 9pt. This entails that in case of having a device with a default em-pixel value lower than 16px the system can scale the text following the defined structure of proportions but none of the text scaled can have an absolute value lower than 9pt, which corresponds to 0.75em on the base of 16px. Having a limited minimum font size of 9pt, which is equal to 12 CSS px, means that in every case the application of the criterion 1.4.4 Resize text will allow the user to visualize the font as a size considered "Large text". The resizing criterion requires the magnification of the fonts up to 200% (W3C - WAI, 2018)so if the smaller text is at 9pt this amplification will transform it into 18pt, the minimum font size for not-bold text to be considered as "Larger text" by WCAG.

Principle Perceivable.Guideline Distinguishable.

SC 1.4.B Minimum font size (Level AA)

"Ensure that the minimum font size displayed corresponds to 12 CSS pixels or its equivalent."

Level AA.
As we have just explained, the font size is used as a baseline for the definition of several success criteria. Nevertheless, the alternative of combining it with other ones such as resizing the text or zooming the screen for solving the possible accessibility issues related to small font size can lead us to propose the success criteria as part of conformance level AA, impacting mainly on users with vision issues.

Intent

The establishment of a minimum text size aims to facilitate the perception of the content for people with vision issues without needing to change the settings and appearance of the content or use assistive technologies. It also serves as a baseline for the correct implementation and limits of related success criteria; in particular, success criterion 1.4.4 Resize text (Level AA). Since that criterion requires the possibility of resizing the text up to 200% the implementation of a minimum font size of 12 CSS px, generally equivalent to 9pt, will allow the displaying of the text at 18pt minimum, which is the lower limit for considering it as "Large text" by WCAG.

In addition, even when resizing the text, the text scale should be coherent and consistent with the structure and hierarchy of the information presented. This means that the proportion between headings, subheadings, paragraphs, etc, should be preserved to ensure better communication of the information and ease its understanding. In the case of using relative units (such as "em") for the definition of the font size structure, the absolute measure equivalent to the minimum "em" should not be less than 9pt. In the general case of using 16px as the default font size for the body, the minimum "em" allowed would be 0.75. This success criterion guarantees that in case of resizing the text, the text content will still be legible in terms of size. The application of minimum font size translates

into a correct and beneficial result of the option Resizing, ensuring the adaptability of the font size to the user needs.

Benefits

- Ensure the visualization of the text content when using the complementary success criterion of resizing
- Ease the perception of the text content
- Set the limits for a correct visualization

Recommendations for implementation

Generally, the default font size used in the devices is 16px, being the equivalent of 1em. Make sure that in case of resizing the text all the resultant text has a minimum font size of 0.75em, which corresponds to 12 CSS px and 9pt.

In case of having a device that uses a different default size, calculate the minimum “em” allowed to ensure that all the text content has a minimum font size of 9pt. The minimum “em” can be calculated by dividing the minimum font size into absolute units (9pt) by the default absolute unit set in the device (e.g 16 px).

min em= 9/default size

4.1.3 Success criterion 1.4.C Minimum image resolution (Level AA)

Justification

Loading speed is a key factor for achieving engagement and having a satisfying User Experience. On average, mobile websites using a 3G connection are able to load the content in 19 seconds. However, only 47% of the users are likely to wait for the content to load if the waiting time is over 3 seconds. Increasing loading speed has become a need for developers in order to improve the User Experience and ensure the number of visits that wait to see the content, especially in the web field

(Think with Google, 2016).

Providing a reduced loading time is one of the five points presented by Google that using accessibility as a baseline, brings benefits for all the users (Cuevas, 2019).

One of the most relevant recommendations for reducing the loading time of a web page or a document is paying attention to the images. The starting point for it is prioritizing the images selected and questioning if they are really necessary, to save the storage needed, especially those which are high resolution or GIFs. Secondly, we should choose the best format for the kind of image we are displaying: JPE for images without transparency, PNG for transparent images and SVG for icons or scalable items. Compressing the images and deleting the metadata will also help to reduce the loading time and the storage needed due to the images (Cuevas & Persoe, 2019).

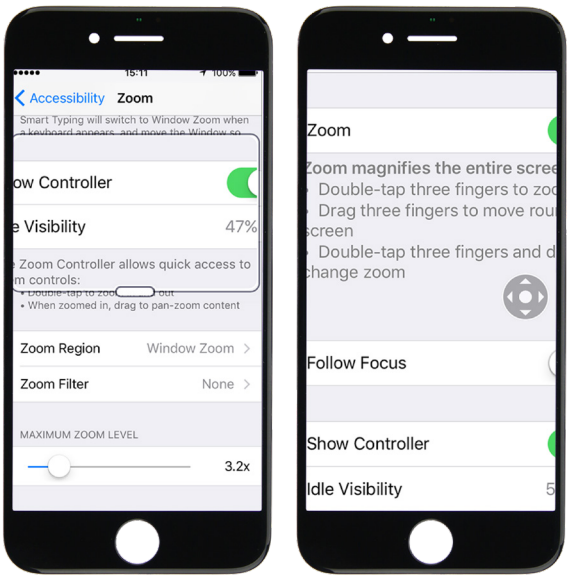

Figure 10. Iphone's UI using screen magnifier on "picture-in-picture" and "fullscreen" mode.

The higher the resolution the larger the file will be, and it will take longer to load the file. That is why the size of the images is being minimized for finding the best balance between size and quality. The minimization and compression of the images to increase the loading speed entails the risk of not being detailed enough to present the information correctly for users who benefit from screen magnifiers. In web content, WCAG defines a maximum of 400% magnification for a responsive system before needing to reflow. In Mobile Devices, Apple sets a default zoom level of 5x on the accessibility features but offers the possibility of variating the zoom level from 1x to 15x to adapt to your needs (Figure 10).

These can have a remarkable impact on the analysis and presentation of charts or complex images.

When using the zoom/screen magnifier mode the different Operating

Systems provide different options for visualization. Microsoft allows the user to zoom in “Full Screen’’ mode, adapting the zoom level using the plus or minus signs and moving around the screen by tapping on the edges. The option “Lens’ ‘ zooms only a reduced area following the pointer or the finger and the option “Docked” allows you to drag anywhere the magnifying dock. Apple applies a similar approach offering the “Fullscreen” mode or the “Picture-in-picture” option which is comparable to the “Docked” and “Lens” mode (Wisconsin Council of the Blind & Visually Impaired, 2018).

Android uses a fullscreen to move around and it is able to enlarge the content up to eight times (Google Support, 2021).

The aim for minimizing the loading time can drive to the excessive compression of images which even when it might not affect the general users, can bring visualization issues for those who use screen magnifiers. Having enough resolution becomes especially relevant for the perception and analysis of images of text (also addressed by WCAG on success criterion 1.4.5 Images of text, level AA) and charts. In order to prevent these issues and ensure the correct visualization of images by screen magnifier users, it is necessary to define the minimum image resolution requested which allows finding the balance between resolution/image size and loading speed.

In many cases, developers provide different versions of an image with different resolutions to optimize the usage according to the visualization device, avoiding using overly-large images in those cases where the display has a small screen by leveraging on responsive design and breakpoints (Saunders, 2018).

As we have already mentioned, WCAG defines a maximum of 400% magnification for a responsive system before needing to reflow, meaning that those images would need to have quality enough for being correctly seen if magnified a 400%. This could lead us to think that the resolution of the image would need to be at least four times the size at which the image will be displayed. However, if we apply this reasoning to big images the resolution needed will be amusing and the size of the file will remarkably increase. In consequence, a new way of defining the minimum resolution needed needs to be defined.

Given the lack of literature found in the topic, which does not allow us to quantify the resolution needed to present it in a statement, the success criterion will be defined without a statement aiming to reach conclusions about its implementation during the interviews with the experts.

Principle Perceivable. Guideline Distinguishable.

SC 1.4.C Minimum image resolution (Level AA)

No statement defined.

Intent

The intention of this success criteria is to set the limits on image resolution for ensuring their correct visualization when using screen magnifiers. The aim of developers for minimizing the image size to increase the loading speed of the websites and Mobile Apps entails the risk of not having enough resolution to successfully present the information to screen magnifiers users. If the resolution is not good enough the result when zooming can be the perception of the image as separated pixels that do not provide accurate information. This is especially relevant for the analysis and perception of graphs or images of text.

Benefits

- Ensuring that resolution is enough to perceive images correctly by users of screen magnifiers
- Preserving the correct visualization of the images when zooming up to 200% Recommendations for implementation

Recommendations for implementation

Choose the adequate format for each picture: JPG for pictures without transparency, PNG for pictures with transparency or using limited and flat colours and SVG for icons and scalable objects.

4.1.4 Success criterion 2.5.A Enable Speech input (Level AA)

Justification

Most of the computers and Mobile devices incorporate today as part of the Operating System Speech recognition for control and input as an accessibility feature. Apart from being used for controlling the actions, it can be useful as an input mode for filling forms or writing texts.

Google uses in Android devices the dictation mode that allows the user to use the voice almost in every case where the keyboard is needed. By installing "Gboard", Google keyboard, they incorporate a little microphone icon that starts the dictation mode when being in a field, using the voice for editing the text written or adding punctuation (Google Support, 2021b).

Microsoft has also developed a Speech control system, by using the icon on the keyboard you can dictate to your device in Spanish, English, Italian, German, French, simplified Chinese and Portuguese; the rest of the languages use the feature Speech recognition, so it is a bit more complex to make corrections or to control the full system (Microsoft Support, 2021).

Apple presents a dictation mode for iPad, iPhones and iPod touch, in earlies models internet connection is needed for performing the transcriptions, but since the iPhone 6s, this feature can be used without requiring any internet connection. The dictation mode is generally activated by default and expressed by the inclusion of the icon of a microphone in the keyboard that activates the Speech recognition when clicked (Figure 11). The system is also able to add punctuation if dictated and special characters (Apple Support, 2021).

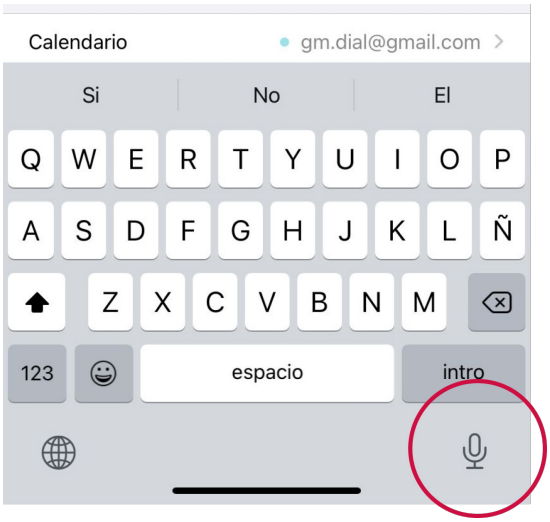

Figure 11. Activation of dictation mode button on Iphone's keyboard.

The limitation to the Speech recognition and dictation mode that Operating Systems have is the languages in which they are developed since not all the languages are accepted.

The problem arises when the code of the App or the webpage overrides the system preferences and disables access to dictation. Using the example given by the accessibility expert Roberto Scano, a member of the WCAG working group, we can see some cases where the apps are not using the standard keyboards but developing their own, which can translate into disabling the dictation mode. Some banks develop their own keyboards for the input of PIN codes or similar features, where they change the order of the numbers for security reasons. If this happens, it is really difficult for blind users to introduce the code since the tiles do not follow the general order. The allowance of Speech input would provide an easy and fast alternative to do it (see Annex A).

Rather than being beneficial only for people with disabilities, it can improve the efficiency of other users. For instance, during the COVID-19 pandemic Doctors and Medical staff needed to spend a great deal of time filling papers and documentation. The implementation of Speech recognition and the allowance of using it on the input fields helped to increase the speed of the process, allowing more time for more important matters than filing the paperwork (Erbis, 2021).

Allowing Speech input is a requirement that is complementing Speech control and assistive technologies to enable users to interact with the device without needing to use their hands, being a key point for users with mobility or execution conditions or preventing some kind of injuries, like Repetitive Stress Injury from getting worse (W3C - WAI, 2016).

Principle Operable. Guideline Input modalities.

SC 2.5.A Enable Speech input (Level AA)

“Every input field allows the use of dictation mode for Speech input.”

Intent

The intent of this Criterion is to ensure that developers respect the availability of dictation mode for input fields. This can be easily accomplished by the use of the standard keyboard provided by the Operating System or by the programming of the specific option in case of developing a customized keyboard. In this way, users relying on Speech control due to lack of mobility, dexterity, execution difficulties, etc. for the navigation on the device can enter all the information required without needing to change the control system or requiring help.

In addition, the implementation and allowance of Speech input, particularly for forms, can increase the speed of the filling process and simplify the interaction with the device. The situational dependence of use is one of the main characteristics of Mobile devices and has pushed the rise of new user behaviours. Benefiting from Speech input can be interesting in situations where the user cannot pay enough attention to the device, like when driving a car, or for embracing neurodiversity, helping users who suffer from learning or cognitive issues.

Benefits

- Facilitate the entering of inputs for users who suffer from dexterity or mobility issues
- Providing an alternative input mode for users with low vision or visual conditions
- Providing an input mode for people who have difficulties for writing, due to cognitive or learning matters
- Giving an alternative input mode for situations where writing is not convenient or comfortable, e.g. for car displays, when there is too much light or when the attention given is reduced
- Assisting people who due to repetition produced conditions or chronic conditions should avoid the use of keyboards
- Ease the use for users with temporary disabilities like broken fingers

Recommendations for implementation

When it comes to Web development, allowing input accessibility is a matter of adding the attribute `x-webkit-speech` to the `<input>` components. In JavaScript, we have to set the boolean `webkitSpeech` as "`true`". In terms of code, some adaptations and limitations are set for each of the languages. However, since Operating Systems usually include Speech recognition and dictation mode as part of their accessibility features the best option is, therefore, using the Standard keyboard respecting the Dictation mode (West, 2014).

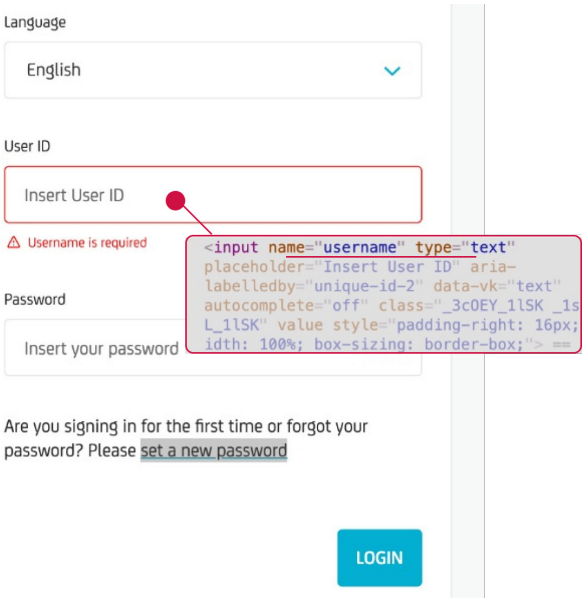

Figure 12. Example of Unicredit input field with unmatching programmed and displayed label (see Annex B).

As we have already mentioned, the allowance of Speech input is a complementary requirement for allowing Speech control. An important fact related to this point is that the visual and programmed labels of the input field should be clearly identifiable and coincident, so the system is able to recognize and identify the target field to fill. If the label displayed says "User ID" but the input field is programmed under the name "Username" the Speech recognition system would not be able to identify the field that the user is trying to edit (the example in figure 12 has been taken from the accessibility audit performed for UniCredit, see Annex B).

4.1.5 Success criterion 2.1.A Alternative to Biometric authentication (Level AA)

Justification

The use of passwords and PINs for authentication can create friction in the User Experience. Passwords are tending to be more and more complex, including a list of requirements to accomplish that leads users to create a great number of passwords that might not be able to remember.

These issues translate into frustration for not being able to log in or even creates security risks because users write their passwords somewhere to access them if they cannot remember them (Nielsen, 2000). Frictions on the User Experience are linked with a loss of revenue like it happens in the case of e-commerce when users are asked to create a password or to log in before being able to purchase the products having problems with authentication can lead to abandoning the shopping process and losing the sale (Nielsen, 2000).

The need for reducing the frictions on the authentication processes and improve the User Experience without damaging security has driven companies towards the implementation of Biometric authentication, which means identifying the users through the analysis of their biological features (Böhm & Testor, n.d.). Some examples of biometric systems and methods are the analysis of fingerprints, hand scans, iris, retina, signature, voice or face. Biometric systems on authentication mode compare the input entered with the one entered by the user the first time, when setting the system, to determine if their match, if the input matches with the identity that they claim to be (Böhm & Testor, n.d.).

Despite providing security reducing the experiential friction, which can be beneficial for the user and for the company, biometric authentication has some limitations that must be considered (Díaz, 2016)and directly related to the topic of this thesis. The company MasterCard stated at the Opus Research Intelligent Authentication 2016 conference the importance of considering the technical, legal and regulatory components of using biometrical authentication and the way they can variate in the near future and depending on the geographic location (Díaz, 2016). The protection of the assets, the security of the storage system and the hardware limitation that it entails are relevant factors affecting the trust of the user (Sequrity Intelligence, 2016). Additionally, in order to preserve security authentication is often approached from a multi-factor, multi-layered, risk-aware perspective, combining biometric authentication with multiple authentication factors layered on top of each other (Sequrity Intelligence, 2016).

Other than the requirements regarding data storage, we can find some other disadvantages of the use of Biometrics derived from the nature and changes on the parameters analyzed. These problems can be classified into

three: noise, distinctiveness and non-universality. Noisy inputs are those that are affected by environmental or external conditions that produce changes in the nature of the data such as changes in the voice because of a cold, a cut in a finger, having wet sensors, a noisy background for voice recognition, etc. These issues can make the authorized person be rejected due to a mismatch between the reference and the sample produced by the noise. Distinctiveness refers to the assumption that different individuals have different biometric parameters. However, there might be close similarities between some individuals, for instance, twins that could translate into the acceptance of the wrong user. Non-universality addresses the impossibility of the use of the biometric trails of some users, some fingerprints might not be detailed enough for allowing biometric recognition or some users might not have the potency to introduce those data, like people who have no hands (Böhm & Testor, n.d.).

It is this last issue of Non-universality, the one that we are addressing with the proposal of this success criterion. The authentication process should be accessible for all users since it is fundamental for the performance of relevant actions. By relying only on biometric authentication we would be leaving apart those users who due to permanent or temporal conditions cannot introduce the required biometric input. In fact, EN 301 549 v2.1.2 already stated that biometric systems must not be used as the only means of authentication (ETSI, 2019). It exists, therefore, the need for the inclusion of an authentication system that does not rely on biometric recognition as an alternative to biometric authentication.

Principle Operable. Guideline Keyboard accessible.

SC 2.1.A Alternative to Biometric authentication (Level AA)

"The platform offers an authentication system not based on biometric authentication."

Intent

This success criterion safeguards the possibility of authentication for those users who due to temporary or permanent conditions cannot rely on the use of biometric parameters for authentication.

The main biometric parameters used for authentication are: fingerprints, hand scan, iris, retina, voice, signature and face. However, each system has the freedom to choose the specific parameter they want to offer the user for performing the authentication. Due to mobility or execution reasons, those users who cannot insert the required type of input need to have an alternative authentication mode not based on biometric parameters, for instance, users who have no hands, speech disabilities, or control the devices without using the touchscreen, using special hardware, eye problems or a great number of different issues.

The exclusive use of biometric authentication would entail the exclusion of those users from the performance of important tasks. Non-universality, together with Noise (a variation on the nature of the samples that prevents the successful identification of the input as correct, like having a cut in the finger, wet hardware or background noise for voice recognition) and Distinctiveness (possibility of allowing the access to the wrong user due to similarities in the input data, as it may happen between twins) are the main problems of biometric authentication that can generate frictions in the User Experience.

In addition, those frictions produced in the User Experience due to the influence of Non-universality, Noise and Distinctiveness can not only affect users with disabilities but general users in frequent situations. Providing an alternative authentication method not based on biometrics would improve the accessibility to the system whenever biometric authentication is not working correctly.

Benefits

- Ensure the possibility for authentication for users who due to temporary or permanent reasons cannot enter required biometric parameters
- Allowing an alternative authentication process for whenever the biometric authentication does not work correctly

Recommendations for implementation

The access to the alternative authentication mode non-biometric based (instructions, link, button, etc.) should be presented on the same screen as a clear, visible and identifiable alternative.

If the chosen alternative authentication mode is a password the requirements for setting it should not be too strict unless is a matter of strong security needed. In this case, we prevent the user from forgetting the password and prolong the duration of the log-in process or even the generation of repeated registrations for the same users (Nielsen, 2000).

Figure 13. Password field including password rules (Nielsen, 2000)

The rules for setting the password should be immediately next to the text label of the password field, as shown in Figure 13.

Not-biometric authentication does not necessarily mean the use of a password that the user needs to remember. There are other authentication systems that provide alternative options such as the generation of QR codes, receiving a one-time password to a linked phone number or mail, using complementary Apps, etc. (Chen & Zhou, 2018). In some cases, these methods are already being used as a part of the two-factor authentication. If using complementary Apps of software as an alternative, this should also offer an alternative to biometric authentication for accessing the keys. The same approach should be followed in case of needing to Re-authenticate due to the expiring of the session. The reference in usability Norman Nielsen's group defends that for non-sensitive applications the time-out per session should be around 1h (Nielsen, 2000). In any case, if Re-authentication is needed the user should not lose any of the information already provided as an input, or in the process, as explained in the complementary Success Criterion 2.2.5 Re-authenticating (Level AAA).

4.2 Validation

The process of developing new WCAG guidelines and criteria requires the involvement of an immense number of stakeholders such as policy-makers, governments and representational institutions, disability associations, accessibility technicians and experts and representatives of important companies, among others. It is obvious then that the development is a long process in time that needs several iterations. In addition, once the new versions are released, they are constantly being reviewed to update any possible data needed.

The validation of this thesis is based on the inclusion of representatives of some of the stakeholders mentioned in order to have a global perspective on the possibilities, interests and plausibility of the criteria proposed. The main means for evaluating them has been the performance of interviews with different experts, each of them belonging to a different stakeholder group. All of the experts are part of the WCAG working group.

Roberto Scano

Roberto Scano is an Italian accessibility expert with great experience in the field. He has represented Italy in the European sectors as a policy-maker for accessibility. He is part of the W3C Accessibility Working Group and has also participated in the generation of European regulations on accessibility and ergonomics and worked as an editor for ATAG guidelines on W3C. Among his publications, we can find the book "Accessibilità delle applicazioni Web" ("Accessibility of web apps") fully dedicated to the accessibility of web apps and "Appunti di accessibilità: WCAG 2.0", ("Notes for the application of web accessibility: WCAG 2.0") the first manual in Italian about the application of WCAG 2.0. In 2018 he was the coordinator of the translation of WCAG 2.1 to Italian. He is currently still an active member of experts' committees from ISO, the European Commission for the European Directive, WCAG and UNINFU (editor and translator of EN 301 549) (Scano, 2021).

Given his experience, he is able to provide a global vision on the working and organization of WCAG and a deep understanding of the stated WCAG criteria while still presenting a great influence on the policy-making process.

Alejandro Moledo

Alejandro Moledo is, since 2013, the current Head of Policy of the European Disability Forum, representing users with disabilities and advocating for them towards the European Parliament. He works for preserving the rights and needs of the users with disabilities by mediating into accessibility policy-making processes regarding standardization, assistive technologies, research or other matters on Information and Communication Technologies. He is the e-accessibility specialist in the European Disability Forum (European Disability Forum, 2021).

His main contribution was applying the user perspective to the success criteria proposed and analyzing the further impact they could have on the standards and their relationship with other complementary existing regulations.

Sheri Byrne Haber

Sheri Byrne Habers presents a 360-degree vision on the issues surrounding accessibility thanks to her complete background which includes knowledge in computer science, law, business, and accessibility competencies. He is an active speaker and writer on disability and accessibility on a blog for medium with over 150 articles that reach about 500000 readers. Her professional pathway has driven her through roles as Principal Accessibility Project analysis on Level and Senior Manager on Global Accessibility for Mc Donald's Corporation and of course as part of the W3C committee (Byrne Haber, 2021).

She has immense experience in the practical application of WCAG guidelines and the impact on the different functional performance criteria which, together with her experience as an analyst on accessibility gives her a precise perspective on the definition of the criteria, their impact and limitations.

The first interview was carried out with Roberto Scano for evaluating the first rough proposal of the Criteria and the interest in their further development, as well as gathering more information about the future plans of WCAG and their area of evolution. Roberto Scano has kept actively supervising the thesis by reviewing the development to ensure the suitability of the document. Once the first iteration of the success criteria has been stated following the structure of justification, statement, intent, benefits and recommendations for implementation, they have been contrasted with other two experts in the field that had introduced new perspectives in the analysis. Alejandro Moledo, as representative of the users, evaluated the direct impact of the criteria proposed in the users and the relations and compatibility of the current European regulation, specifically with the EN 304 549 v.3.2.1 and the European Accessibility Act and the Directive 2016/2102. On the other hand, Sheri Byrne Haber Provides the practical experience and expertise for the statement and definition of the success criteria given her experience on W3C, and a large number of researches and articles she wrote in the field.

The following subchapter gathers the feedback given by these experts on the new success criteria proposed before proceeding to the statement of a second iteration including them.

4.2.1 Feedback on the first success criteria proposed

The following table (Table 4) presents a summary of the feedback obtained for each success criterion and general feedback of the interest of the topic and its impact based on the interviews performed with the experts. For each expert, we can find a column where to express their general agreement with the need and suitability of each criterion. The column “feedback” collects the total specific feedback gathered during the interviews.

Success Criterion	Scano	Moledo	Byrne Haber	Feedback
Enable Dark mode	✓	✓	✓	• Always provide light mode as default • Remember if the user chose dark mode • Focus and interactions also should comply with contrast • Attention to the links, they might not be accessible
Minimum font size	✓	✓	✗	• Problematic with smartwatches • Maybe different sizes for sans serif or serif • Controversy inside WCAG but they decided on Resize text • Consider expressing it in CSS px
Minimum image resolution	✓	✓	✓	• Do not define a specific limitation but offer the user the option to load a high-resolution picture • Refer to non-decorative images
Enable Speech input	✓	✓	✗	• Rely on the device configuration • Might not match with the WCAG catalogue since the justification would be ignoring another criterion
Alternative to Biometric authentication	✓	✓	✓	• Already considered. Present it as an expansion of the new criterion on WCAG v2.2 SC 3.3.7 Accessible authentication • The system should remember the preferences

General feedback	✓	✓	✓	• They might also have a great impact on UAAG • Include relationship with functional categories

✓ Agrees with the implementation

✗ Disagrees with the implementation

Table 4. Summary of the feedback received for each success criterion proposed.

Success Criterion 1.4.A Enable dark mode (Level AA)

As we have already mentioned some users can have many struggles with dark mode. The decreasing of the legibility makes it prejudicial for people with dyslexia but it can be beneficial for some users with cognitive conditions given the way it helps to focus the attention on charts. In addition, it might present difficulties for users who suffer from colour blindness, it is very difficult to perceive red and green colours on dark background and it is hard to comply with the contrast regulation for some present colours such as the in-text link (blue) and the already read link (red). Consequently, releasing only dark mode is not allowed. However, as we have previously explained, it has benefits for users with and without disabilities, such as helping with photophobic conditions and being easier to see in a dimly lit room (Byrne Haber, 2019), so the proposal of it as a new success criterion to help those users is still interesting (Byrne Haber, see Annex A).

- The user should be allowed to easily change from light to dark mode to adapt the system to his/her needs. The criteria should include as part of the recommendations for implementation that the system should remember the option chosen by the user and select it automatically when using it (Byrne Haber, see Annex A).
- Special attention should be given to the colours so they comply with the contrast regulation, including those for indicating focus and interactive components (Byrne Haber, see Annex A).
- In-text links might be difficult to perceive due to their set colours, blue and red (for the already opened) (Byrne Haber, see Annex A).

Success Criterion 1.4.B Minimum font size (Level AA)

When it comes to font size we can find different opinions, as was already warned by Scano in the preliminary interview (see Annex A). There are controversies on whether minimum font size should be defined, the main argument against it is the existence of mobile devices with really reduced screen sizes such as smartwatches. The definition of an absolute minimum size will mean the limitation of the amount of information displayed in these devices while users might still be able to read smaller fonts.

Byrne Haber explained (see Annex A) that as long as the success criterion 1.4.4 Resize text is respected, the user will be able to adapt the font size to an adequate size for him/her. The existing criterion for resizing requires the possibility of resizing the text, images of text and captions up to 200% larger, meaning that a small font size as 6pt could be displayed as a 12pt font.

Nevertheless, we should consider that the main Operating Systems recommend a lower font size 10pt or 9pt, meaning that the resizing of the font 200% would always be presented equally or above 18pt, turning to be considered as "Large text" by W3C (W3C - WAI, 2018). On the contrary, if the original font size is below 9pt even with resizing, it will still not be considered as "Large text" unless it is bold (bold font of at least 14pt is considered "large text").

Further than the discussion on if it is necessary or not to be included, the proposal received other feedback to be taken into account.

Legibility is also dependent on the type of font used, the colour and complementary parameters such as the tracking, the spacing between words, or paragraphs. The colour contrast and the space-related issue are also addressed by WCAG. However, the type of font is not regulated and could affect the minimum size allowed. As Byrne Haber explained during the interview (see Annex A), sans serif fonts is more legible than serif fonts, so while the limitation of 9pt can be enough for sans serif fonts for serif fonts it might be necessary to be larger. It is something that could be explored. However, the reasoning of the combination of minimum font size and resize criteria would still ensure the visualization of all content as "Large text" if needed.

In addition, Byrne Haber recommended the use of CSS pixels (CSS px) as the main unit since that is the one chosen for defining the target size or any other absolute measurement established. One CSS pixel corresponds with 1:96 inches (see Annex A).

Success Criterion 1.4.C Minimum image resolution (Level AA)

As it can be seen in Annexe C: experts' interviews and as reflected in Table 4, all the experts consulted agreed on the interest and utility of this criterion for ensuring the correct visualization of the images by users benefiting from screen readers, especially for the analysis and understanding of images of text (addressed by WCAG and proposing alternatives) and charts.

Moledo highlighted the importance of requirements only for those images that are informative and not for the only decorative ones (see Annex A). However, none of the experts was able to provide a reference to define the minimum resolution requested. The main reason behind this absence is the need for optimization of the image sizes in order to increase the loading speed. The preliminary idea was to define a minimum resolution for each image of two times the size it would be displayed. In this way, if magnifying the screen up to 200% the visualization would still be a reasonable size. Notwithstanding, the implementation of this approach on large images would entail the need of loading remarkably large images, lowering the loading speed and creating a pain point in the user experience (Think with Google, 2016). This issue together with the lack of references to sustain it led to the search for a new approach.

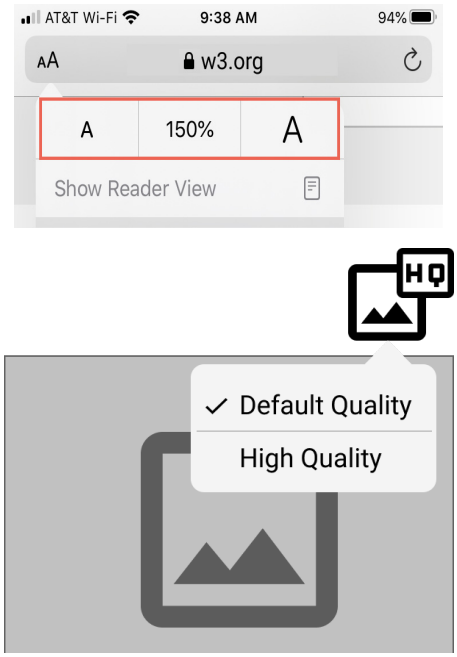

Figure 14. Parallelism between the font size regulator and a proposal of image resolution control

Rather than giving by default a high-quality image the system should give the user the option of loading a high-quality image if needed (Byrne Haber, 2021). Following the example of the shortcut button appearing in some systems for changing the font size

represented as Figure 14, an option could be implemented for easily allowing the user to load a high-resolution version of the image to be examined using a screen magnifier without entailing a lack of quality. Because of this discussion and the new possibilities that enabled this success criterion will be rephrased in the next subchapter.

Success Criterion 2.5.A Enable Speech input (Level AA)

The reasoning for the proposal of this criterion was to ensure the possibility of filling input fields by speech, protecting the users from the cases where a customized keyboard is overriding the default settings of the system. Both Scano and Moledo were very positive about the inclusion of this criterion since speech control provides access to a large number of users and explained that speech input is normally included in the devices by default, but some platforms may override it to use their customize keyboards or preferences (Scano, see Annex A). However, Byrne Haber was reluctant explaining that the justification for this criteria is the unfulfillment of success criterion 2.4.1 Character Key shortcuts and that if this one is compliant the proposed one is not needed (see Annex A). Character Key shortcuts requires that the user can remap the shortcuts and turn them off if they wish (W3C - WAI, 2018), but the remapping should be chosen by the user and not by the system. In addition, Byrne Haber exposed that WCAG does not address the enabling or disabling of assistive technologies considering it out of the catalogue.

Nonetheless, she highlighted the importance of the related point mentioned as part of the recommendations for implementation consisting of requiring that the programmed label for identifying each input field must match with the label visually displayed in order to allow speech control users to communicate with the system and choose the field they want (Byrne Haber, see Annex A).

My personal opinion about the proposed criteria "2.5.A Enabling speech input" is that it would reinforce and clarify the need for not overriding this feature since the link between this need and success criterion 2.4.1 Character Key shortcut is not direct. In addition, as reflected in Table 4, the criterion was positively evaluated by most of the experts. In consequence, it will be stated as an expansion of the already existing criterion 2.4.1 Character Key shortcut to actively manifest the need for respecting speech input.

Success Criterion 2.1.C Alternative to Biometric authentication (Level AA)

This criterion initially arose during the preliminary call with Scano. It has already been proposed on the EN 301 549 V.3.2.1 and it was interesting to include it. Byrne Haber remarked that there is a similar criterion upcoming in WCAG 2.2 in November called 3.3.7 Accessible authentication (level A). It is part of a new guideline created "Input assistance" which is part of the Understandable principle.

The criterion states: "For each step in an authentication process that relies on a cognitive function test, at least one other authentication method is available that does not rely on a cognitive function test, or a mechanism is available to assist the user in completing the cognitive function test." (W3C (WAI), 2021a).

As it can be appreciated, the accessible authentication provided only addresses cognitive-based methods. There is, therefore, the need of including some references to biometric authentication since it is also one of the most used methods that comprise several options (Byrne Haber, see Annex A). The success criterion proposed 2.1.A Alternative to biometric authentication should be then included as part of criterion 3.3.7 Accessible authentication added to the requirements related to cognitive-based methods or a modification of this criterion and division into two different ones should be needed.

In addition, one of the recommendations for implementation that should be added is asking the system to remember once more the option chosen by the user. In this way, if a user cannot use biometric authentication the system will be providing him/her with an alternative method automatically (Byrne Haber, see Annex A).

General comments and impact.

During the interview (see Annex A), Moledo highlighted the impact that the proposed success criteria have on complementary guidelines such as the User Agent Accessibility Guidelines (UAAG). Some of the criteria such as Enabling Dark mode, Enabling speech input and providing an Alternative to Biometric authentication are also applicable to browsers or

Operating Systems and could be, therefore, also proposed as part of the UAAG in order to increase the impact and the reach.

In addition, Moledo believes that the future development of Accessibility Guidelines will have an approach more similar to the one proposed in this thesis, being more comprehensive and aiming to address the existing relationships between the different existing guidelines, for content (WCAG), for User Agents (UAAG), for Authoring Tools (ATAG), etc. (see Annex A).

Byrne Haber explains (see Annex A) that the regulation should be kept as device-independent as possible. However, the criteria proposed can also have a relevant impact if applied on desktop devices.

4.3 Second iteration of the success criteria

To highlight the differences and changes between the first iteration and the second one the information already defined on the first iteration is displayed in grey, and all the changes in black colour. In addition, those changes are identified using lateral square brackets.

4.3.1 Success criterion 1.4.A Enable Dark mode (Level AA)

Principle Perceivable. Guideline Distinguishable.

SC 1.4.A Enable Dark mode (Level AA)

"Dark mode is enabled for the necessary platforms and fulfils the contrast requirements for text and non/text content."

Intent

This Criterion provides an alternative UI visualization that reduces the amount of light by relying on negative contrast polarity (light text on dark background). The intent of this success criterion is to ease the perception

of the UI for people who are affected by photophobic conditions or suffer from some types of visual impairment such as Cloudy Ocular Media.

The continuous use of positive contrast polarity (light mode) is associated with the development of myopia and some users prefer to set the dark mode for specific occasions in order to reduce the impact on the ambience and avoid disturbing other people around, for instance, being in the cinema.

By providing both UI, positive contrast polarity based, and negative contrast polarity based, the user has the option to choose the one that adapts better to his/her visual needs and improve the accessibility for some visually impaired users.

Benefits

- Photophobic users stand better the reduced amount of light coming from the screen
- Users with Cloudy Ocular Media have a better perception
- Enhances the perception of charts
- Reduce possible risks of developing myopia due to long term use

Recommendations for implementation

Summary:

- Allow dark mode respecting the system preferences
- Test the UI in both, light and dark mode
- Preserve the predominance of dark ambience
- Reduce the use of colours and leverage on dynamic colour systems
- Ensure contrast ratios in all layers
- Use desaturated light colours
- Adapt icons, symbols, glyphs and images using asset catalogues
- The colours for focused elements and interactive states should also comply with the contrast regulation

NEW

- Provide light mode by default and present the option for changing it in a clear and visual way

NEW

- If the user selects dark mode, the system should remember the choice and display dark mode automatically the next time.

The last versions of the most famous Operating System offer Dark Mode as a possible default interface style for displaying the information giving even the option to schedule them. In order to provide a smooth transition of the interfaces of the apps to this style, the designers and developers need to allow the app to embrace the system preferences and respect them.

A document created using default colour for the text and default for the background can easily be adapted to dark mode if the user chooses it, by using its default colour, but if you are setting the text colour to green you are forcing the user to visualize it that way. In the same way, if the background colour of the app is set as default the system will adapt it to the new requirements (Scano, see Annex A).

Apart from using default modes for the design, the interface should always be tested in both modes to make sure that the contrast between the elements is correct and the interface can be correctly visualized. Not all the designs work correctly in both modes. Pay attention to legibility and ease of reading, especially in the case of having backgrounds affected by transparency. Contrast requirements specified in success criteria 1.4.3 Contrast (Minimum) and 1.4.11 Non-text contrast should be respected. In addition, images need to be chosen or adapted to fit in both contexts by using assets catalogues.

Colours:

The dark mode is characterized by using darker background colours and lighter foregrounds. Google guidelines defend the use of dark grey rather than black as a background colour to have a wider range for creating elevations by applying layers of slightly lighter colours on top of each other and enhance the perception of depth. These lighting layers that make the elements feel closer to the user are created by applying transparency layers on top of the components using On Surface Colours (see Figure 9) (Google Design, 2021a).

Colour contrast should be compliant in all the elevation layers. Google

Material states that in order to preserve the legibility on the highest and lightest surfaces, and comply with success criterion 1.4.3 Contrast (Minimum) level AA (4.5:1) the contrast between text and the darkest background colour needs to be 15.8:1. (Google Design, 2021a).

When using colours it is recommended to add colours set to the assets and components to make them dynamic and define the different variations (dark and light mode) depending on the mode instead of using hard-coded colour values (Apple Inc., 2021f).

In case of needing to use white colour, rather than using pure white it should darken a bit to emit less light. Saturated colours do not comply with the regulation on Dark Mode and they can produce eye strain. It is better to reduce the use of the Accent colour as much as possible to preserve the general darkness and use desaturated colours for improving the contrast.

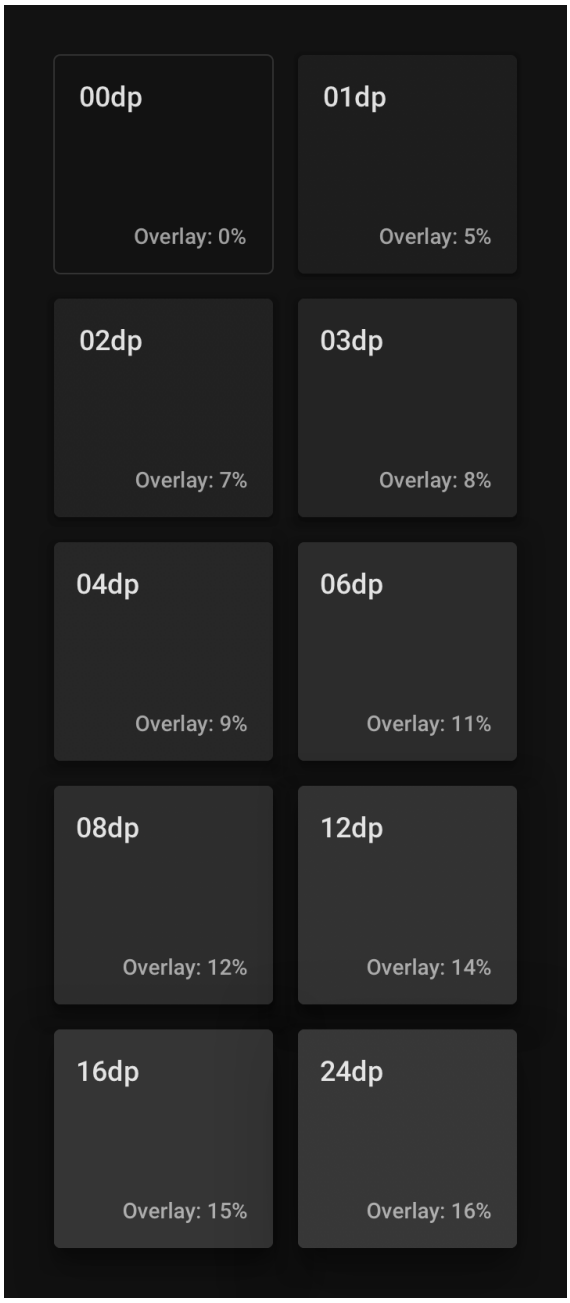

Figure 9. Definition of transparency layers on dark mode on Google Design (Google Design, 2021a).

4.3.2 Success Criterion 1.4.B Minimum font size (Level AA)

Principle Perceivable. Guideline Distinguishable.

1.4.B Minimum font size (Level AA)

NEW

"Ensure that the minimum font size displayed corresponds to 12 CSS px or its equivalent."

Level AA.

As we have just explained, the font size is used as a baseline for the definition of several success criteria. Nevertheless, the alternative of combining it with other ones such as resizing the text or zooming the screen for solving the possible accessibility issues related to small font size can lead us to propose the success criteria as part of conformance level AA, impacting mainly on users with vision issues.

Intent

The establishment of a minimum text size aims to facilitate the perception of the content for people with vision issues without needing to change the settings and appearance of the content or use assistive technologies. It also serves as a baseline for the correct implementation and limits of related success criteria; in particular, success criterion 1.4.4 Resize text (Level AA). Since that criterion requires the possibility of resizing the text up to 200% the implementation of a minimum font size of 12 CSS px, generally equivalent to 9pt, will allow the displaying of the text at 18pt minimum, which is the lower limit for considering it as "Large text" by WCAG.

In addition, even when resizing the text, the text scale should be coherent and consistent with the structure and hierarchy of the information presented. This means that the proportion between headings, subheadings, paragraphs, etc, should be preserved to ensure better communication of the information and ease its understanding. In the case of using relative units (such as "em") for the definition of the font size structure, the absolute measure equivalent to the minimum "em" should not be less

than 9pt. In the general case of using 16px as the default font size for the body, the minimum “em” allowed would be 0.75. This success criterion guarantees that in case of resizing the text, the text content will still be legible in terms of size. The application of minimum font size translates into a correct and beneficial result of the option Resizing, ensuring the adaptability of the font size to the user needs.

Benefits

- Ensure the visualization of the text content when using the complementary success criterion of resizing
- Ease the perception of the text content
- Set the limits for a correct visualization

Recommendations for implementation

Generally, the default font size used in the devices is 16px, being the equivalent of 1em. Make sure that in case of resizing the text all the resultant text has a minimum font size of 0.75em, which corresponds to 12 CSS px and 9pt.

In case of having a device that uses a different default size, calculate the minimum “em” allowed to ensure that all the text content has a minimum font size of 9pt. The minimum “em” can be calculated by dividing the minimum font size into absolute units (9pt) by the default absolute unit set in the device (e.g 16 px).

min em= 9/default size

4.3.3 Success Criterion 1.4.C High-resolution image (Level AA)

Principle Perceivable. Guideline Distinguishable.

SC 1.4.C Minimum image resolution (Level AA)

NEW

"For images providing information a mechanism for visualizing a high-resolution version of the image is available."

Intent

The intention of this success criteria is to provide an image with resolution enough for ensuring the correct visualization of the content by users using screen magnifiers. The aim of developers for minimizing the image size to increase the loading speed of the websites and Mobile Apps entails the risk of not having enough resolution to successfully present the information to screen magnifiers users. If the resolution is not good enough the result when zooming can be the perception of the image as separated pixels that do not provide accurate information. This is especially relevant for the analysis and perception of graphs or images of text.

NEW

However, the unnecessary load of high-resolution images for accommodating screen readers can translate into an extended loading time for the platforms, entailing negative impacts on the user experience. This criterion aims to find a balance between the resolution and the loading speed by suggesting the implementation of a system to load high-quality images providing information if the user requires so.

Benefits

- Ensuring that resolution is enough to perceive images correctly by users of screen magnifiers
- Preserving the correct visualization of the images when zooming up to 200% Recommendations for implementation

Recommendations for implementation

NEW

Following the existing example on some mobile browsers of including a shortcut to the preferences of font size, it is recommended to include a button or shortcut to load an image of better quality if required by the user (example given in Figure 14).

In order to control the loading speed, the activation of this option should be provided only in those images containing information.

Choose the adequate format for each picture: JPG for pictures without transparency, PNG for pictures with transparency or using limited and flat colours and SVG for icons and scalable objects.

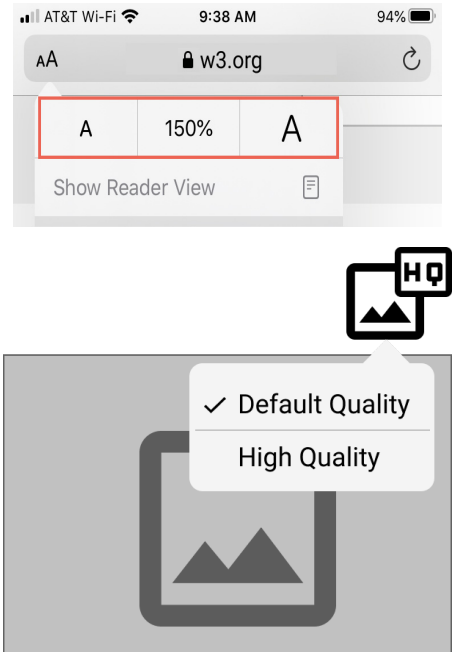

Figure 14. Parallelism between the font size regulator and a proposal of image resolution control

4.3.4 Expansion to Success Criterion 2.4.1 Character Key Shortcut: Enable Speech input (Level A)

Principle Operable. Guideline Keyboard accessible.

SC 2.4.1 Character Key Shortcut (Level A)

"If a keyboard shortcut is implemented in content using only letter (including upper- and lower-case letters), punctuation, number, or symbol characters, then at least one of the following is true:

- **Turn off: A mechanism is available to turn the shortcut off;**
- **Remap: A mechanism is available to remap the shortcut to use one or more non-printable keyboard characters (e.g. Ctrl, Alt, etc);**
- **Active only on focus: The keyboard shortcut for a user interface component is only active when that component has focus." (W3C - WAI, 2018).**

Success Criterion expansion: Enable Speech input

NEW

"Every input field allows the use of dictation mode for Speech input."

Intent of the expansion

NEW

This criterion requires the possibility of remapping the shortcuts on the keyboard if the user requires so and to provide a mechanism to turn them off. However, if the user does not request the remapping or disabled of the shortcuts the system should not do it by itself, nor remap the tiles conforming the keyboard in order to remain identifiable by users with some conditions.

The intent of this expansion of the criterion that refers to the enabling of speech input is to ensure that developers respect the availability of dictation mode for input fields.

This can be easily accomplished by the use of the standard keyboard provided by the Operating System or by the programming of the specific option in case of developing a customized keyboard. In this way, users

relying on Speech control due to lack of mobility, dexterity, execution difficulties, etc. for the navigation on the device can enter all the information required without needing to change the control system or requiring help.

In addition, the implementation and allowance of Speech input, particularly for forms, can increase the speed of the filling process and simplify the interaction with the device. The situational dependence of use is one of the main characteristics of Mobile devices and has pushed the rise of new user behaviours. Benefiting from Speech input can be interesting in situations where the user cannot pay enough attention to the device, like when driving a car, or for embracing neurodiversity, helping users who suffer from learning or cognitive issues.

Benefits of the expansion

- To facilitate the entering of inputs for users who suffer from dexterity or mobility issues
- Providing an alternative input mode for users with low vision or visual conditions
- Providing an input mode for people who have difficulties for writing, due to cognitive or learning matters
- Giving an alternative input mode for situations where writing is not convenient or comfortable, e.g. for car displays, when there is too much light or when the attention given is reduced
- Assisting people who due to repetition produced conditions or chronic conditions should avoid the use of keyboards
- To ease the use for users with temporary or permanent disabilities who cannot enter the required biometric input

Recommendations for implementation of the expansion

When it comes to Web development, allowing input accessibility is a matter of adding the attribute `x-webkit-speech` to the `<input>` components. In JavaScript, we have to set the boolean `webkitSpeech` as "`true`". In terms of code, some adaptations and limitations are set for each of the languages. However, since Operating Systems usually include

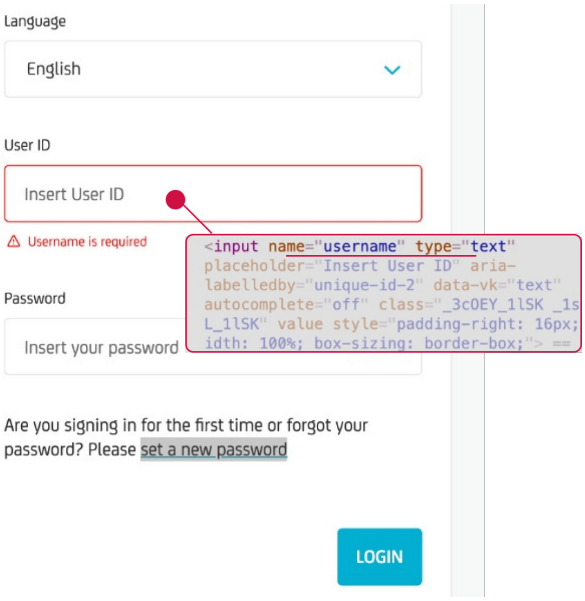

Figure 12. Example of Unicredit input field with unmatching programmed and displayed label (see Annex B).

Speech recognition and dictation mode as part of their accessibility features the best option is, therefore, using the Standard keyboard respecting the Dictation mode (West, 2014). As we have already mentioned, the allowance of Speech input is a complementary requirement for allowing Speech control. An important fact related to this point is that the visual and programmed labels of the input field should be clearly identifiable and coincident, so the system is able to recognize and identify the target field to fill. If the label displayed says "User ID" but the input field is programmed under the name "Username" the Speech recognition system would not be able to identify the field that the user is trying to edit (example in Figure 12).

NEW

In any case, it is recommended to rely on the default configuration set on the device leveraging on the options and layout of the already included keyboard, respecting the preferences of the operating system.

4.3.5 Expansion to Success Criterion 3.3.7 Accessible Authentication: Alternative to Biometric authentication (Level A) Upcoming on WCAG 2.2.

Principle Understandable. Guideline Input assistance.

SC 3.3.7 Accessible Authentication (Level A) Original statement`

"For each step in an authentication process that relies on a cognitive function test, at least one other authentication method is available that does not rely on a cognitive function test, or a mechanism is available to assist the user in completing the cognitive function test." (W3C - WAI, 2021).

SC 3.3.7 Accessible Authentication (Level A) Suggested statement`

NEW

"For each step in an authentication process that relies on a cognitive function test, or biometric factors at least one other authentication method is available that does not rely on a cognitive function test, or biometric data respectively, or a mechanism is available to assist the user in completing the cognitive function test."

Success Criterion expansion 1: Processes that rely on a cognitive function test.

Current information on the original criterion 3.3.7 Accessible Authentication.

Success Criterion expansion 2: Alternative to biometric Authentication

The platform offers an authentication system not based on biometric authentication.

Intent of the expansion 2

This success criterion safeguards the possibility of authentication for those users who due to temporary or permanent conditions cannot rely on the use of biometric parameters for authentication.

The main biometric parameters used for authentication are: fingerprints, hand scan, iris, retina, voice, signature and face. However, each system has the freedom to choose the specific parameter they want to offer the user for performing the authentication. Due to mobility or execution reasons, those users who cannot insert the required type of input need to have an alternative authentication mode not based on biometric parameters, for instance, users who have no hands, speech disabilities, or control the devices without using the touchscreen, using special hardware, eye problems or a great number of different issues.

The exclusive use of biometric authentication would entail the exclusion of those users from the performance of important tasks. Non-universality, together with Noise (a variation on the nature of the samples that prevents

the successful identification of the input as correct, like having a cut in the finger, wet hardware or background noise for voice recognition) and Distinctiveness (possibility of allowing access to the wrong user due to similarities in the input data, as it may happen between twins) are the main problems of biometric authentication that can generate frictions in the User Experience.

In addition, those frictions produced in the User Experience due to the influence of Non-universality, Noise and Distinctiveness can not only affect users with disabilities but general users in frequent situations. Providing an alternative authentication method not based on biometrics would improve the accessibility to the system whenever biometric authentication is not working correctly.

Benefits of the expansion 2

- To ensure the possibility for authentication for users who due to temporary or permanent reasons cannot enter required biometric parameters
- Allowing an alternative authentication process for whenever the biometric authentication does not work correctly

Recommendations for implementation of the expansion 2

The access to the alternative authentication mode non-biometric based (instructions, link, button, etc.) should be presented on the same screen as a clear, visible and identifiable alternative.

If the chosen alternative authentication mode is a password the requirements for setting it should not be too strict unless it is a matter of strong security needed. In this case, we prevent the user from forgetting the password and prolong the duration of the log-in process or even the generation of repeated registrations for the same users (Nielsen, 2000). The rules for setting the password should be immediately next to the text label of the password field, as shown in Figure 13.

Figure 13. Password field including password rules (Nielsen, 2000)

Not-biometric authentication does not necessarily mean the use of a password that the user needs to remember. There are other authentication systems that provide alternative options such as the generation of QR codes, receiving a one-time password to a linked phone number or mail, using complementary Apps, etc. (Chen & Zhou, 2018). In some cases, these methods are already being used as a part of the two-factor authentication. If using complementary Apps of software as an alternative, this should also offer an alternative to biometric authentication for accessing the keys.

The same approach should be followed in case of needing to Re-authenticate due to the expiring of the session. The reference in usability Norman Nielsen's group defends that for non-sensitive applications the time-out per session should be around 1h (Nielsen, 2000). In any case, if Re-authentication is needed the user should not lose any of the information already provided as an input, or in the process, as explained in the complementary Success Criterion 2.2.5 Re-authenticating (Level AAA).

NEW

If possible, the system should remember the authentication method chosen by the user to present it as default the next time that is required in order to minimize the interactions and reduce the frictions appearing on the user experience due to the performance of repetitive actions.

4.4 Mapping of the impact of the new success criteria on functional categories

The following table (Table 5) has been created to illustrate and summarize the impact and relevance of the success criteria proposed on each of the functional categories presented in WCAG. The reference for functional categories has been taken from version 3.0 since it presents a more detailed approach and highlights the importance of addressing cognitive and learning issues.

The idea promoting the generation of this mapping comes from following the example provided by the GSA Government about Section 508, where we find the mapping of the WCAG 2.0 Success Criteria with the proposed Functional Performance Criteria of Section 508. That table and the expansion of it including the success criteria presented in this research can be found in Annex C (Table C.2) and has been validated in the experts' interviews performed (see Annex A).

The mapping of the success criteria and functional categories remarks the importance of complying with all the success criteria to achieve accessibility, showing that the noncompliance with one of them might result in the discrimination of people with conditions belonging to a specific functional category.

Func. categ. vs WCAG 3.0 SC	Speech	Attention	Language Literacy	Memory	Vision Visual	Mobility	Motor	Physical Sensory intersec.	Executive	Mental health	Cognitive Sensory intersec.
1.4.A Enable Dark mode	-	X	-	X	X	-	-	X	-	-	X
1.4.B Minimum font size	-	-	-	-	X	-	-	-	-	-	X
1.4.C High-resolution image	-	-	-	-	X	-	-	X	-	-	-
2.4.1 Exp. Enable Speech input	-	X	X	-	X	X	X	X	X	X	X
3.3.7 Exp. Alternative to Biometric authentication	X	-	-	-	X	X	X	X	X	-	X

Table 5. Mapping of the impact of the new success criteria on Functional categories

4.5 Future lines

When it comes to the future versions of WCAG, both of the current working documents of the WCAG working group, version 2.2 and 3.0, are planning on addressing more directly Mobile accessibility but, furthermore, given the fast evolution of technology and the long development time required for the Standards, the new versions will most probably include some requirements for other rising technologies such as Augmented realities and Artificial Intelligence, two of the main current discussion topics (Scano, see Annex A). In fact, W3C has already published a draft of the first XR accessibility requirements in order to understand the challenges and accessibility issues appearing in immersive or augmented scenarios. head-mounted devices and head and positional tracking capabilities (W3C (WAI), 2020d).

"Augmented reality overlies digital content and information onto the physical world" (Google, 2021a). It displays the current reality you are adding extra elements digitally created or information about it. This technology can have a great impact on providing new services and User Experiences. It is available for mobile devices and includes applications such as visual recognition of things by checking them with the camera, creating immersive experiences, providing explanations on the cities, restaurants, directions, etc. by pointing your live surroundings in the camera, and much more (example Figure 15). In short, it opens a great number of possibilities for developers and users and the implications regarding accessibility should be studied and addressed in order to provide access to all the users and allow them to benefit from its features.

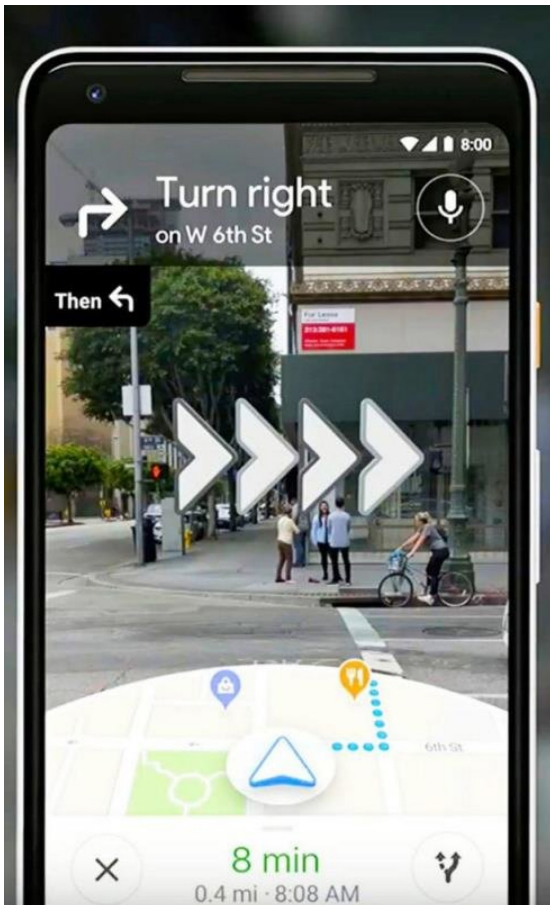

Figure 15. Google Maps using augmented reality (Kumar Sharma, 2020)

According to John McCarthy Artificial Intelligence "Is the science and engineering of making intelligent machines, especially

intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable." (McCarthy, 2004). It is the valuable principle of products and services that are gathering importance in our daily life; from a thermostat that is able to adjust the temperature according to your habits to self-driven cars, Artificial Intelligence is generating more and more opportunities to improve our lives. Some of its more common applications are game-playing, speech recognition, understanding natural languages, computer vision, expert systems (e.g. performing medical diagnoses) or heuristic classification (McCarthy, 2004). Once more, given the vast range of opportunities, it is clear that its correct application can have a highly remarkable impact in supporting the user and enabling people with disabilities to perform some tasks more easily.

As a consequence of their potential impact, both of the technologies mentioned, Augmented reality and Artificial Intelligence, it becomes necessary to set some guidelines and standards where developers, designing and users can refer for ensuring accessibility and bringing new benefits to people (Scano, see Annex A). The rising of these technologies will bring new opportunities but can also bring new ways of discrimination (Moledo, see Annex A).

Concerning the future lines of the specific success criteria proposal stated in this thesis, the need for further development relies on two clear points. On the one hand, more exploration of the code and development area would be needed. WCAG is complemented with other regulations such as ARIA, that they frequently refer to the non-normative section named "Sufficient techniques". The exploration of the coding possibilities and limitations is a key factor in the development of WCAG to guarantee that the implementation of the Criteria can be achieved.

On the other hand, it would be necessary to perform user tests for each of the success criteria proposed, evaluating the influence on the performance of users with and without disabilities to generate different iterations that can lead to a better accessibility level.

We should be aware that the development of new versions of WCAG and new success criteria has an impressive amount of work behind it and

it involves in the process a great number of stakeholders, policymakers and experts from different fields. Companies such as Apple, Google, IBM or Microsoft provide experts and support for the working groups of WCAG, ISO and the European Board aiming to transfer and combine their knowledge and work (Scano, see Annex A). As we have explained, each version goes through different stages and iterations until reaching the final sufficient level of clarity and quality and that once published, they are reviewed on a general basis.

Further than the generation of guidelines for new technologies, there might be a change in the structure and concept of WCAG. As we have already seen, version 3.0 proposes a completely new system changing the structure and the evaluation system aiming to make them more understandable and easier to be evaluated by the users. Added to these changes, Moledo explains that future guidelines might explore the relationship between the different areas (Content, User Agents, Authoring Tools, etc.) and apply a more comprehensive approach towards them, addressing the impact they provoke in each other (see Annex A).

4.6 Conclusions

The purpose of this thesis was to identify possible pain points and opportunities in WCAG guidelines for improving accessibility on mobile devices starting from the main differences existing in the user experience between mobile and desktop devices.

The result of the research has been the proposal of a total of three new success criteria and two expansions for existing ones that have been evaluated by experts in the matter. The following table (Table 6) presents a summary of the second iteration (performed including the feedback received) of the success criteria specifying the statement and the main benefits of their application.

SC 1.4.A Enable Dark Mode

Statement:

"The dark mode is enabled for the necessary platforms and fulfils the contrast requirements for text and non-text content."

Benefits:

- Photophobic users stand better the reduced amount of light coming from the screen
- Users with Cloudy Ocular Media have a better perception
- Enhances the perception of charts
- Reduces the possibilities of developing myopia due to long term use

SC 1.4.B Minimum font size

Statement:

"Ensure that the minimum font size displayed corresponds to 12 CSS px or its equivalent."

Benefits:

- Ensures the visualization of the text content when using the complementary success criterion of resizing
- Eases the perception of the text content
- Sets the limits for a correct visualization
- myopia due to long term use

SC 1.4.C High-resolution image

Statement:

"For images providing information a mechanism for visualizing a high-resolution version of the image is available."

Benefits:

- Ensuring that resolution is enough to perceive images correctly by users of screen magnifiers
- Preserving the correct visualization of the images when zooming up to 200% Recommendations for implementation

Expansion to SC 2.4.1 Character Key Shortcut: Enable Speech input

Statement:

"Every input field allows the use of dictation mode for Speech input."

Benefits:

- To facilitate the entering of inputs for users who suffer from dexterity or mobility issues
- Providing an alternative input mode for users with low vision or visual conditions
- Providing an input mode for people

	who have difficulties for writing, due to cognitive or learning matters • Giving an alternative input mode for situations where writing is not convenient or comfortable, e.g. for car displays, when there is too much light or when the attention given is reduced • Assisting people who due to repetition produced conditions or chronic conditions should avoid the use of keyboards • To ease the use for users with temporary or permanent disabilities who cannot enter the required biometric input
Expansion to SC 3.3.7 Accessible Authentication: Alternative to Biometric Authentication	
Statement: "The platform offers an authentication system not based on biometric authentication."	Benefits: • To ensure the possibility for authentication for users who due to temporary or permanent reasons cannot enter required biometric parameters • Allowing an alternative authentication process for whenever the biometric authentication does not work correctly

Table 6. Summary of the second iteration of the success criteria: statement and benefits.

We can reflect that apart from improving accessibility on mobile devices the application of these criteria has a positive impact on the accessibility conditions on desktop devices. In addition, some of them may have an interesting relationship with complementary guidelines proposed by W3C such as ATAG and UAAG and can therefore be perceived as having a broader approach to accessibility comprising factors further than content.

In short, the implementation of new guidelines and criteria on WCAG requires a broader exploration of the topic, involving numerous

stakeholders and complementing them with user testing and coding development. However, the proposed criteria 1.4.A Enable Dark mode, 1.4.B Minimum font size, 1.4.C High-resolution image and the two expansion 2.4.1 Character key shortcut: Enable Speech input and 3.3.7 Accessible Authentication: Alternative to Biometric Authentication represent some of the opportunities of development of WCAG being an interesting starting point for contributing to the improvement of the regulations on mobile accessibility.

The continuous development of the regulations to improve accessibility implies the need of evolving with the new technologies and devices. The proposal presented focuses on the use of mobile devices to give them the protagonism they have nowadays. In order to sustain the criteria and ensure their impact on accessibility, it is necessary to continue with the development in complementary areas such as coding and the adaptation to different platforms and Operating Systems. In addition, it would be important to increase the collaboration with user associations and perform user tests to understand the repercussions and adequacy for the different disabilities and the complexity it implies. It is necessary to question the regulations and to propose new success criteria, even though not all of them will reach the final step, to work on a continuous improvement system. Finally, we should be aware that we have set the focus on WCAG, but there are several complementary regulations that have space for improvement and could also be the centre of future research.

Annexes

Include a mini table of content

Annex A:

Experts' interviews

In order to validate the proposal resulting from this thesis and ensuring its relevance in the field and the achievement of the goals set we organize interviews with experts in the field. The first interview was performed with Roberto Scano to corroborate the suitability of the preliminary criteria proposed and explore the possible opportunities for developing others. After the success of this interview, two more interviews were scheduled with other experts to evaluate the first complete iteration of the criteria and gather feedback to develop a second iteration. The experts who participated in this phase were Alejandro Moledo del Río and Sheri Byrne Haber. In addition, Scano continued following the progress and actively participating by proposing adjustments. As part of the interviews, we also discussed the future lines of development of WCAG and its relationship with upcoming technologies.

This annex collects the transcriptions of the interviews providing the explanatory slide that served as a recap of the information given to the experts. Each of the interviews includes a small presentation of the background of the expert.

29/07/21
Scano

Roberto Scano is an accessibility expert that, among others, has participated in the edition, preparation and translation of the EN 301 549 v2.1.2. In addition, he is a member of the WCAG working group and from the Web Accessibility Directive expert group of the European Commission, where he is part of the national representation for policymaking. He has vast experience in the field and a great vision of European regulation (Scano, 2021).

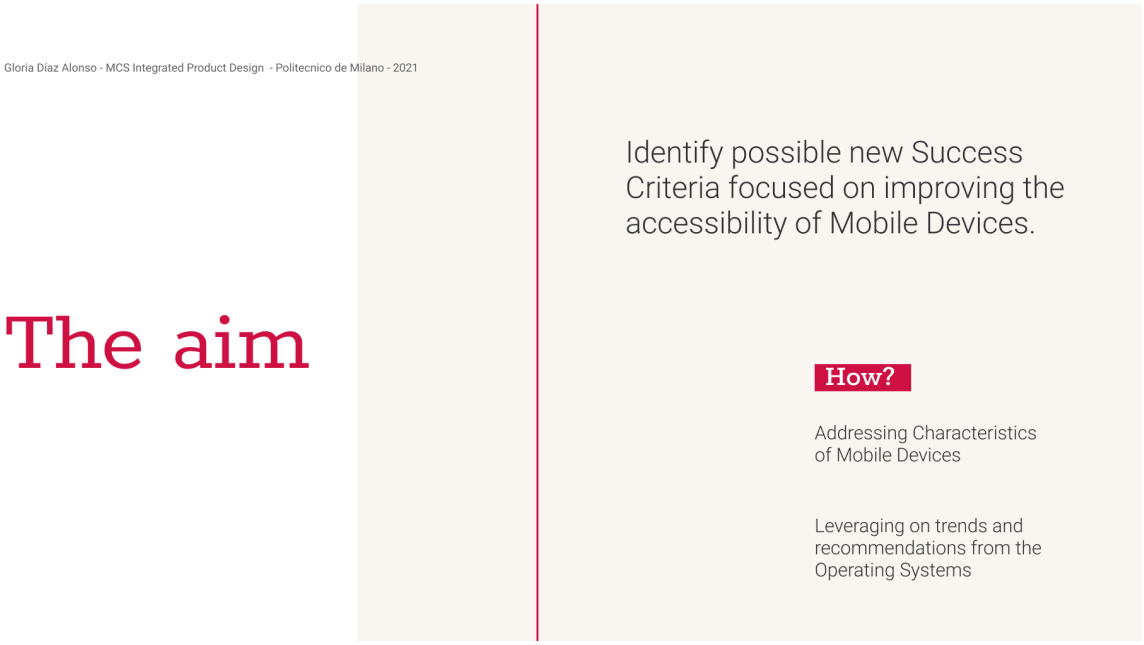

Figure A.1. Slide for expert presentation: aim of the thesis.

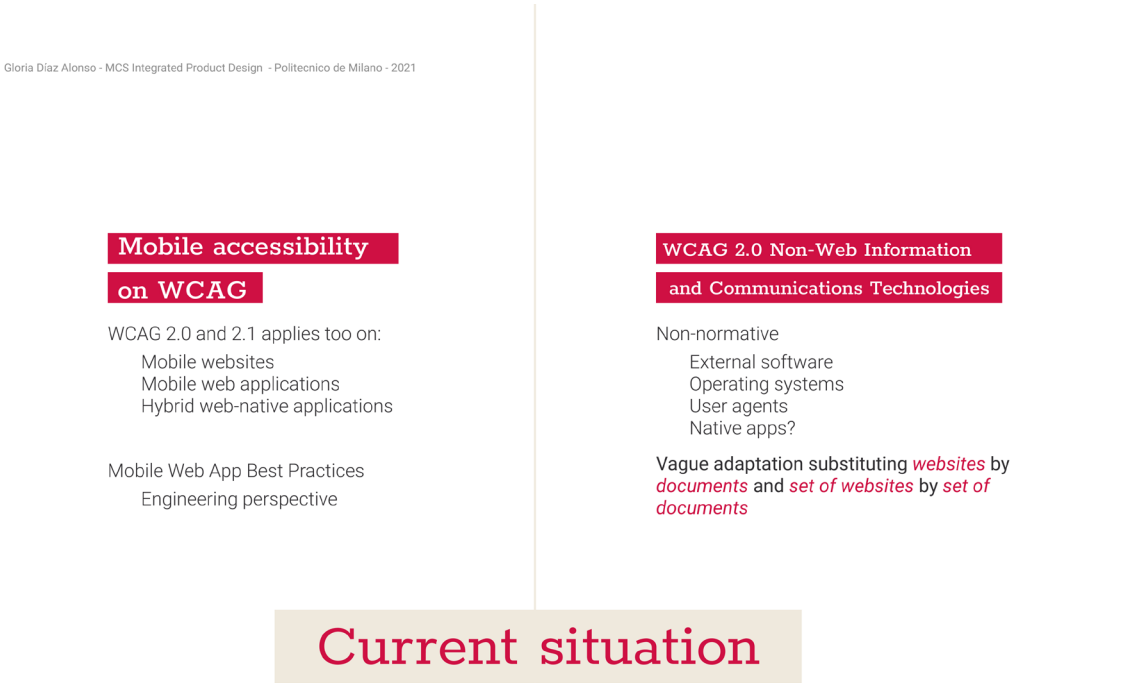

Figure A.2. Slide for expert presentation: main WCAG references.

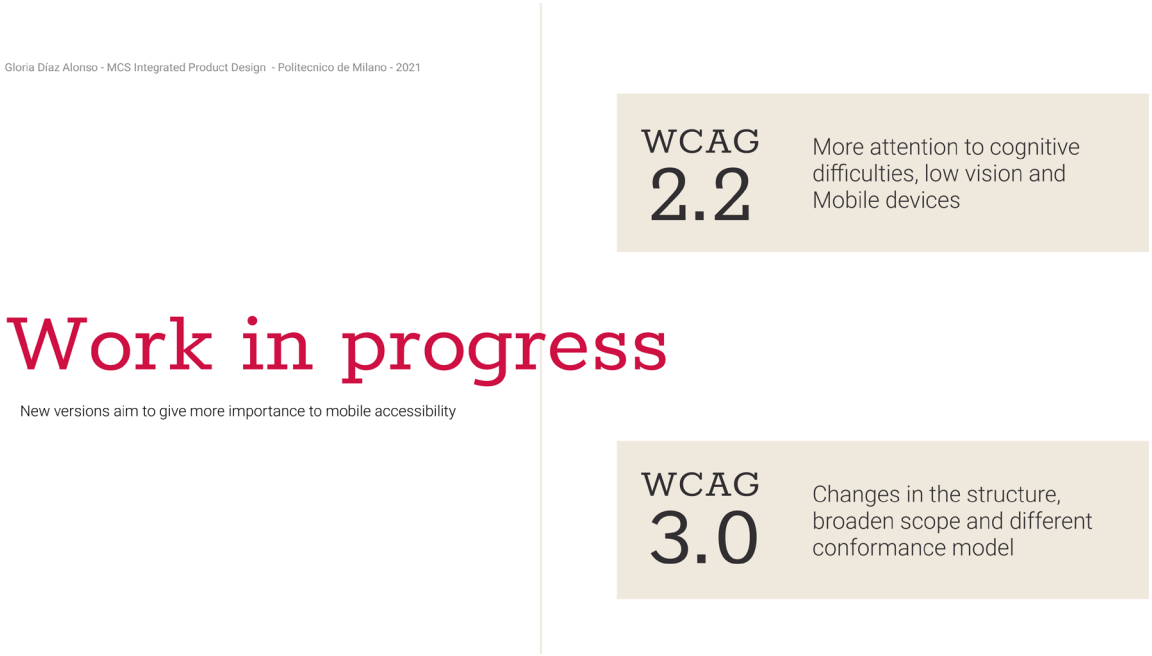

Figure A.3. Slide for expert presentation: future versions of WCAG.

Roberto Scano: Version 3.0 will be a big change. For ten years we have been discussing the importance of each single Success Criteria, when you evaluate the conformance according to level A and level AA you have about 50 Criteria that need to be evaluated and fulfilled. You cannot say "ok, I comply with everything but two, so I am good". No, because those two might have a great impact, imagine you have a website where the main content is videos, and all the Success Criteria are compliant but the one for video caption; you would be leaving out of the content to people who are different. Every Success Criteria is important because each of them targets specific disabilities.

When you evaluate a website, you can use automatic checkers and validators but many of the issues related to mobility cannot be examinate that way and they need to be manually evaluated. Out of the 50 criteria companies that provide automatic checkers can guaranty the correct evaluation of around 20, the other ones need to be manually checked.

Figure A.4. Slide for expert presentation: characteristics of mobile devices

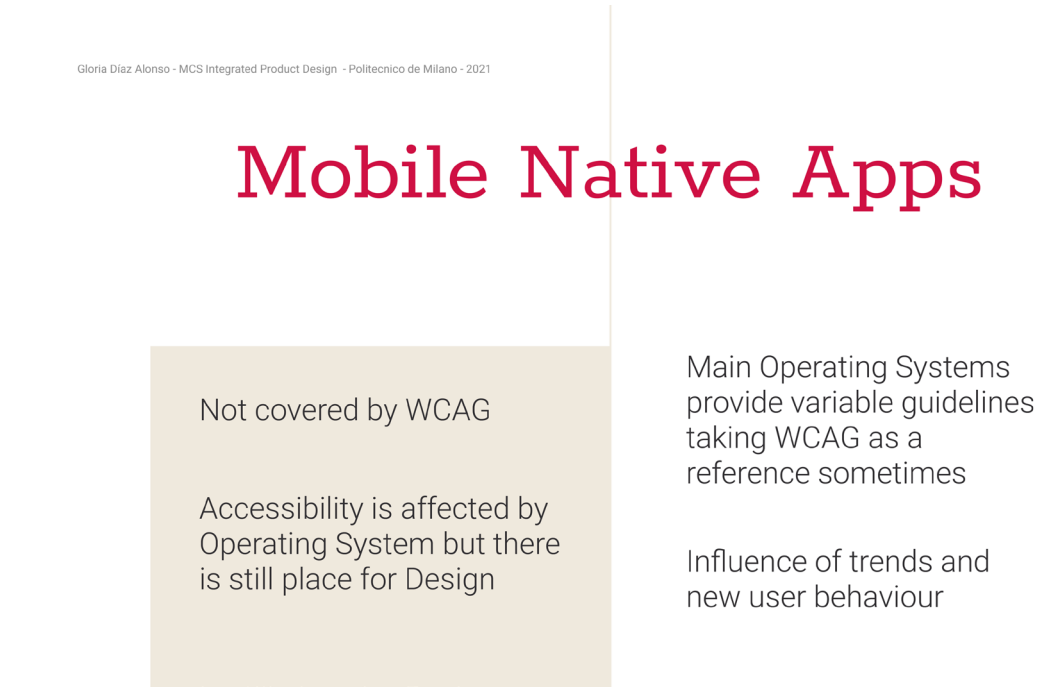

Figure A.5. Slide for expert presentation: importance of mobile native apps.

Roberto Scano: We also have that issue when we developed European Standard, if you download them there is a table in annex A.2 where we set the requirements for Mobile devices. If you see, we don't refer to the WCAG directly but to the Software requirements. For example, if you have an app that uses Biometric authentication you should also need other authentication means. I think that table on annex A2 on the European Standard would be useful for your thesis since it has the rules for native apps. I think this will still be the reference for the next five or ten years.

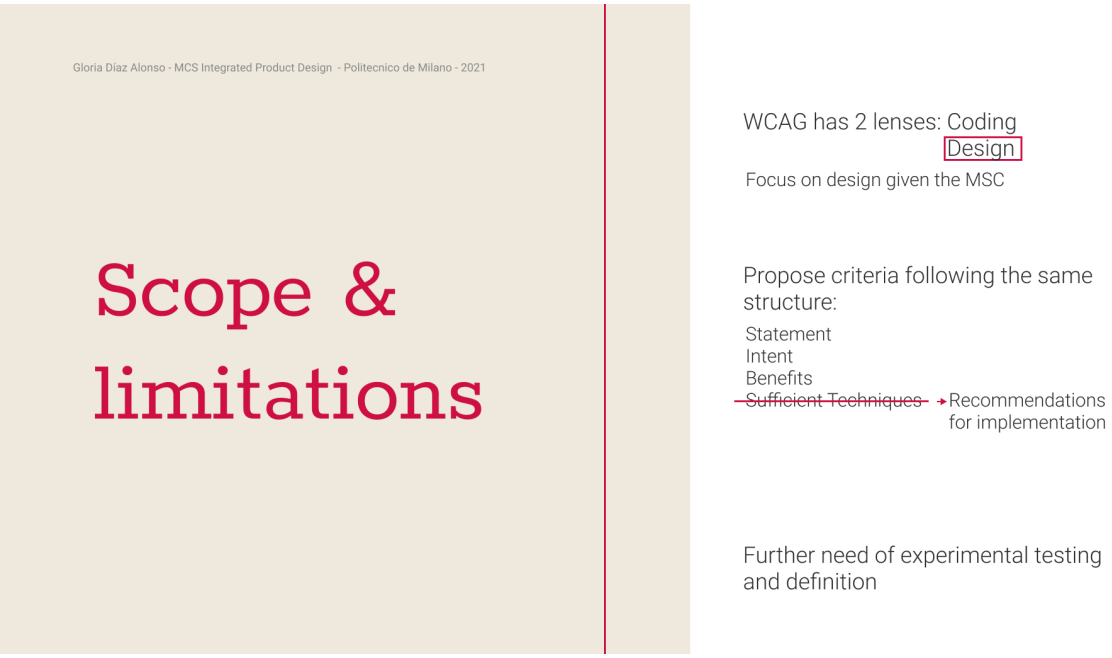

Figure A.6. Slide for expert presentation: scope and limitations of the thesis

Roberto Scano: All the techniques and understanding documents are non-normative because we change them very often, even once a week, we always specify that they are examples. You can also comply with the Success Criteria by using different techniques, we just try to provide some examples to help to understand the Criteria.

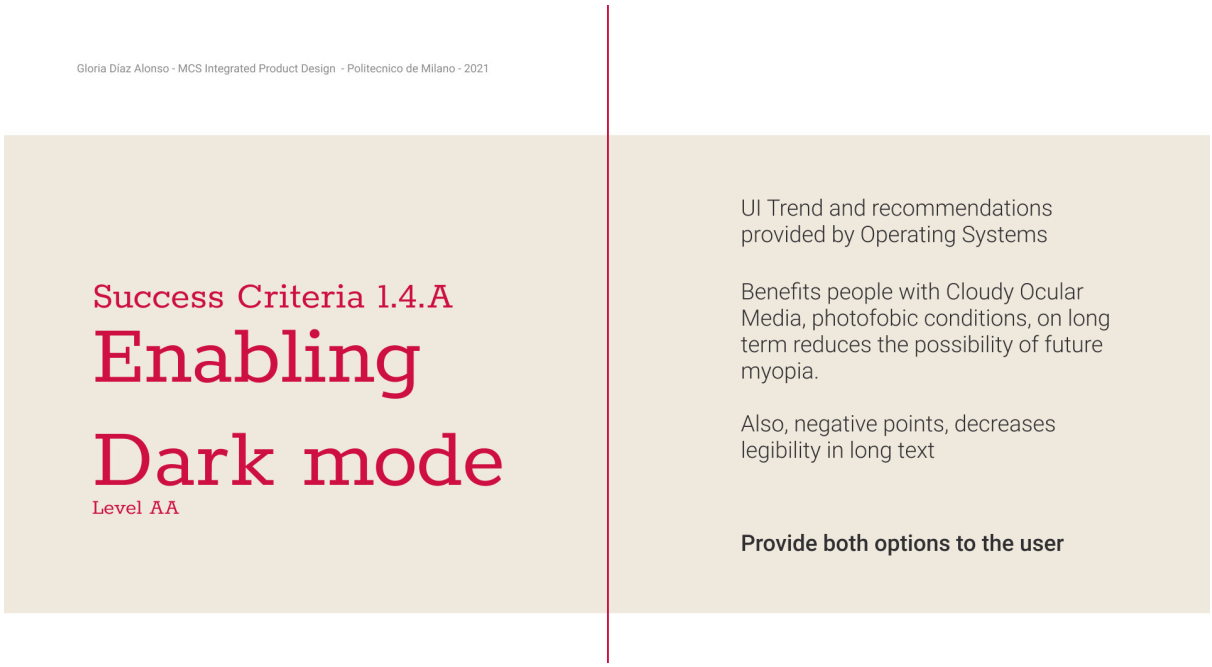

Figure A.7. Slide for expert presentation: Justification of Enabling Dark Mode

Roberto Scano: This one is not considered in WCAG but might be mentioned in the Annex A2 of the European Standard by saying that everyone who develops software needs to expand the configuration defined by the user inside the operating system. If I increase the font size, I want it to be increased in the app, if I change to Dark mode it should be used in the app. In general, the main Operating Systems offer you easy ways to achieve it but sometimes is the developer the one that does not allow it, like disabling the rotation of the screen.

Gloria Díaz: I understand that in this case, the Operating System can allow the dark mode but, in any case, as a designer, you should make sure that the UI is adaptable.

Roberto Scano: Sure. It is the same in documents. If you create a text document and you set the text colour as the default colour and you convert the document, share it to a user that has activated the Dark mode, the text changes the colour to that which has been defined as the main colour. If you set the colour of the text to green you are forcing the user to visualize it that way. The same thing happens in the Apps. If you have a default background colour the dark mode automatically adapts it to the new requirements, while if you set a green background in hard mode inside the colour it will still be green in the dark mode. So, I support this Success Criterion.

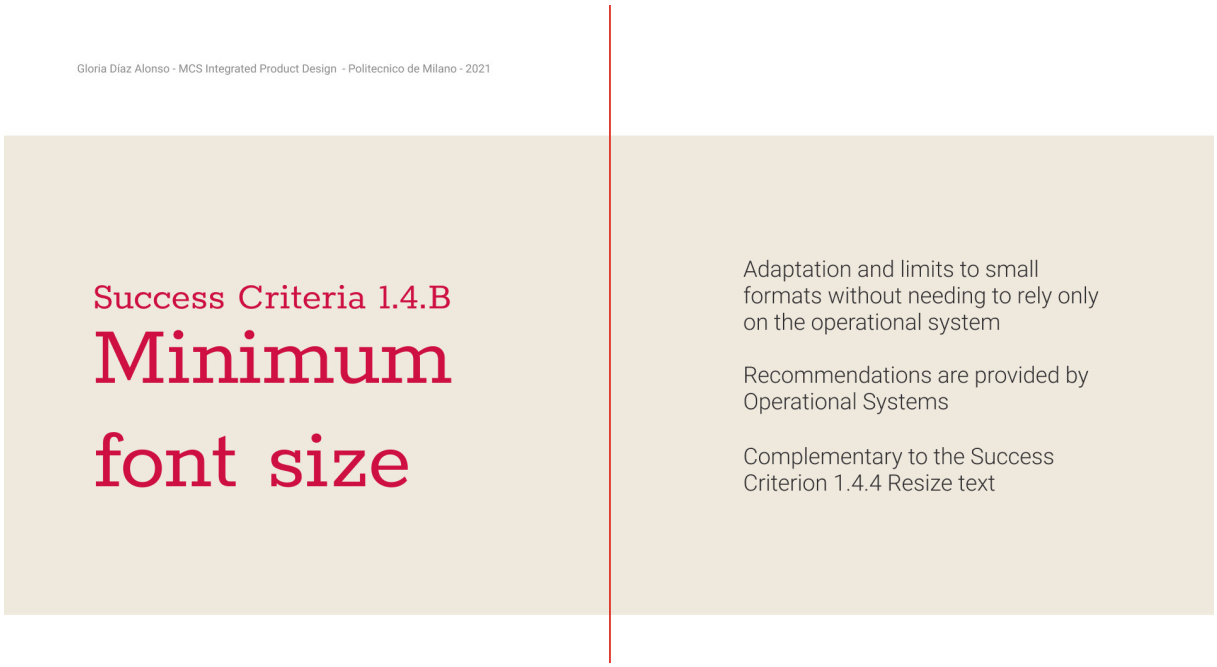

Figure A.8. Slide for expert presentation: Justification of Minimum font size

Roberto Scano: When we discussed font sizes around 2002 the idea was that the developer should set the font size to 1em, being the base of relative measures so when I set large text in my App it will easily change the configuration. The issue that is related to the minimum text size is re-flow, to make sure that the app is responsive enough for presenting the large text without interferences. I think inside the WCAG group would be like setting a "religious war" but I think it would be a good idea.

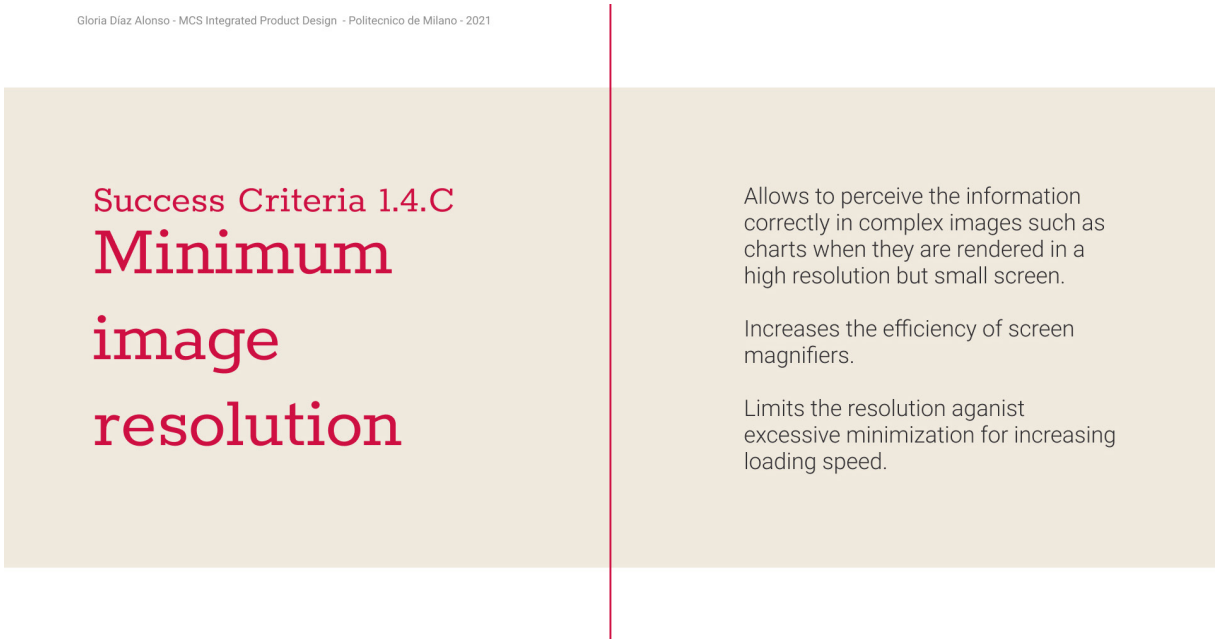

Figure A.9. Slide for expert presentation: Justification of Minimum image resolution.

Roberto Scano: Yes, I like it, it is right.

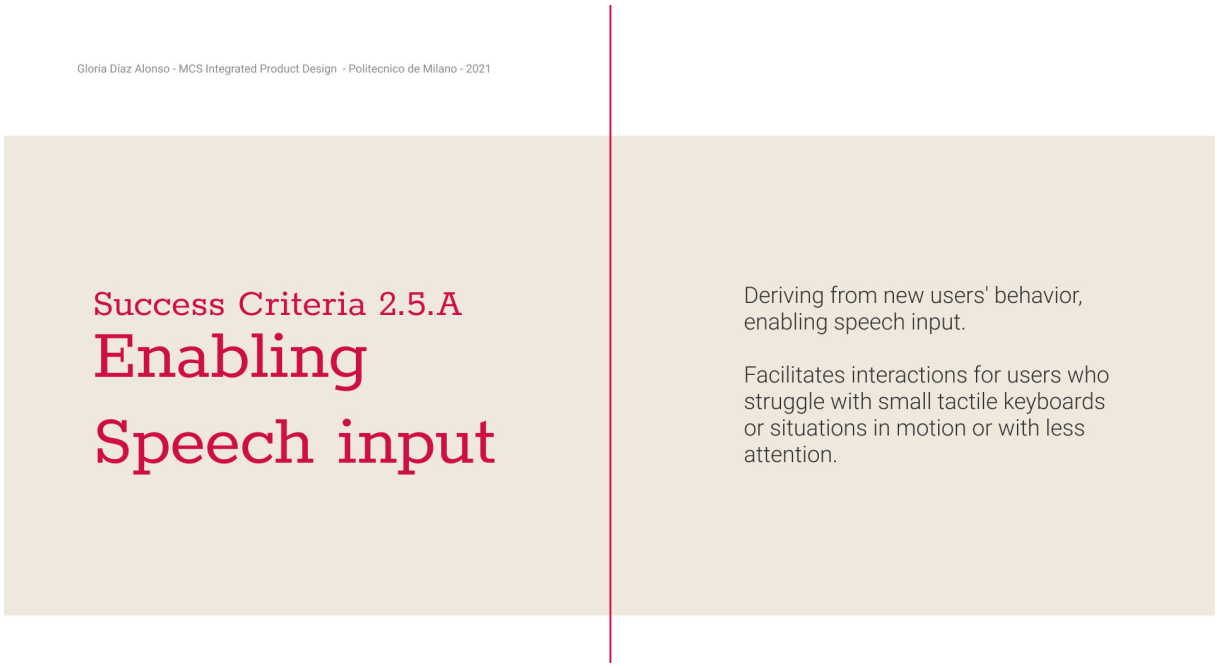

Figure A.10. Slide for expert presentation: Justification of enabling speech input.

Roberto Scano: Another suggestion is to tell the developer to rely on the configuration of objects to the ones provided by the Operating System. If you use the standard keyboard the microphone is enabled but if the developers create their own customize keyboard you can have this issue. We have similar problems when an app is requiring entering a pin or a password. If you use the default keyboard, I can recognize the single keys and choose them, if you use a custom keyboard, you can generate problems for some users. For instance, banks are sometimes developing a keyboard for pins where they change the order of the numbers for security reasons, changing the order of the numbers and presenting them (9,7,5,2,4...). In this case, it is very difficult for blind users or users with cognitive disabilities to fill the pin code. The idea to let the user use the voice is perfect.

Some years ago, I also work for supporting Amazon Echo, another example of how the voice would be useful for interacting with technology. As you said, having the possibility to use speech input in every field is great.

I would suggest for this Criterion that the developer does not disable the option of speech input, because you do not need to include it but rather just not disable it.

OTHER QUESTIONS

Gloria Díaz: What might be the perspective of WCAG on Mobile accessibility on version 3.0?

Roberto Scano: From version 2.0 we have been trying to make it independent from the kind of content. Version 1.0 was explicitly related to HTML, CSS, javascript, etc. 2.0 moved to another definition. In the EN standard, we talk about web content, web documents and not web documents. 3.0 will be a total redesign. I think we will need 4 years, 5 years to do it, we are still on the very first draft even though the expected delivery was by the end of 2020. I think we will add a lot on Mobile accessibility but I think we will add also some new requirements related to Mobile apps and their applications, think about augmented reality; it is one of the main topics that are in discussion now. Also about Artificial Intelligence, that can support the user. In this case, we also need to set some guidelines.

Many things depend on web evolution, web technology and mobile technology so we need to sit down and think about how they can be influenced by accessibility. We discussed a lot some month ago, it was the boom of "Clubhouse" where you interact with voice and the main issue was what would happen with deaf people, how could they interact? A similar thing was proposed before by twitter but when they got notice that this technology without captions would discriminate against people, they stop the launching of the product. Inside WCAG we have a lot of requirements that can be applied to some emerging technologies and some new ways of interaction but, as we say, if something new is not addressed we need to propose a new Success Criterion and release a new version of WCAG.

3.0 I believe it is a total change, it is an early draft, so it is difficult to talk about it. So far personally it has something I don't like, it has the bronze, silver and gold medal for the Success Criteria, but it is not a competition, we need to be compliant. I think we are stopping on 2.2 but we could be continuing with 2.3 for some requirements of the European Community. 3.0 is a big jump taking a big risk, we first need to take a big step and then secure the accessibility. WAI has not only WCAG, which is only for web content, but many other guidelines related to different topics.

Gloria Díaz: Which impact does WCAG have on Operating Systems? Is there any collaboration with the main developers?

Roberto Scano: WCAG are more oriented to the web content, so the main impact is on the browser. WCAG has many ISO standards. I have worked for 9421, 951 and 971 that was related to software and operative systems and there we extracted some requirements that are similar to WCAG, apply good contrast, don't rely only on colour, resize text, etc. operating systems developers are very interested in including these requirements into the operating system, since if you implemented directly you make them more accessible, so they provide a lot of accessibility options (screen readers, create captions automatically, etc.).

Gloria Díaz: Operating systems can provide a lot of accessibility options, but we still need to design the apps for making them compatible and profiting from those opportunities.

Roberto Scano: Yes, inside the WCAG, the ISO, the European Board there are people from Microsoft, from Apple, from Google, IMB and many stakeholders that are participating in supporting the development of WCAG and transferring the knowledge into their companies to implement coherent accessibility into their companies. The standard will be more and more important and compulsory not only for public administration but for companies. If your products are not accessible some employees might not be able to use them, and that is discrimination that can put the company in front of a judge for discriminating in the working environment. It is a guarantee for them and the possibility of inclusion for people with disabilities.

I think that you can add the one that is suggested in the EN standard, the biometric access. The possibility to access a service not only biometrically, but you also need to guarantee another access.

Gloria Díaz: Further than Mobile devices, what would be the future lines for development on WCAG? Have virtual/mixed/augmented reality been considered?

Already replied in the first question.

19/08/21
Moledo

Alejandro Moledo del Río is since already eight years ago the current Head of Policy - European Disability Forum. They work for the representation of people with disabilities in policymakers and the generation of Standards such as the EN 301 549 V3.2.1. As an advocacy organization, they get constant updates on the regulations generated by WCAG and collaborate with organisations such as the European Parliament, the European Commission or the Council of the EU to defend the interest of people with disabilities (European Disability Forum, 2021).

Figure A.1. Slide for expert presentation: aim of the thesis.

Figure A.4. Slide for expert presentation: characteristics of mobile devices

Alejandro Moledo: About the specific characteristics of Mobile devices. I would also add "close functionality" as one of the main characteristics, which means that you cannot add assistive technologies, like downloading and installing your own screen reader but need to rely on the Operating System. I don't know if they are considered as SAT closed functionalities as an ATM but the accessibility features of the device are built-in. It can have bad sides and good sides. The EN 301 549 v3.2.1 Standard includes a full chapter on close functionality so it might be worthy to mention.

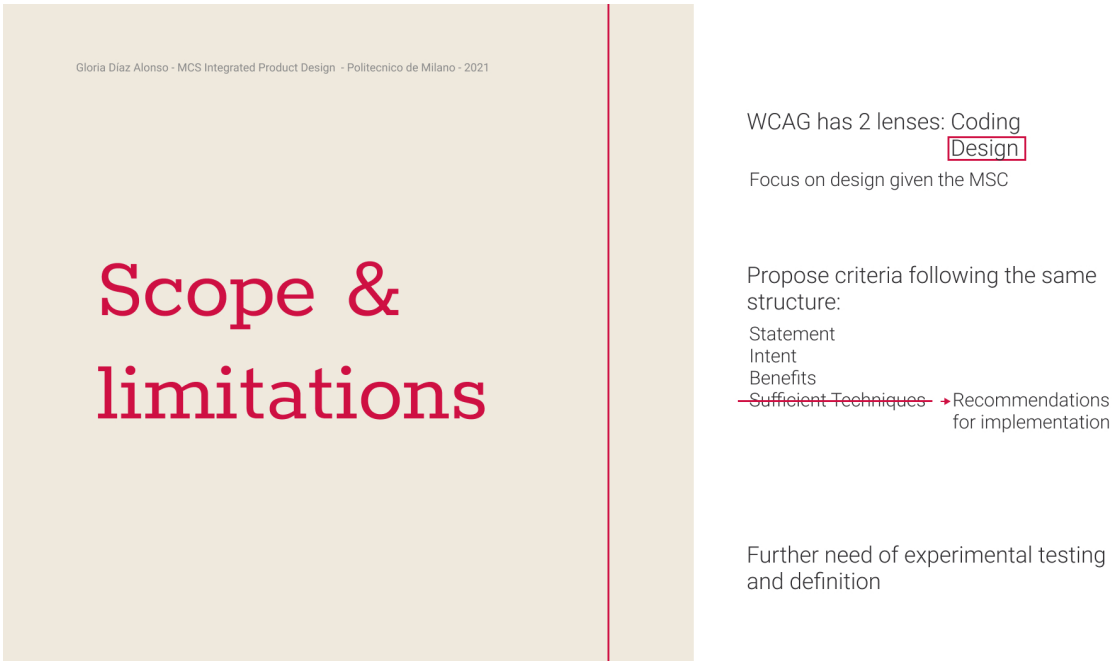

Figure A.6. Slide for expert presentation: scope and limitations of the thesis

Figure A.7. Slide for expert presentation: Justification of Enabling Dark Mode

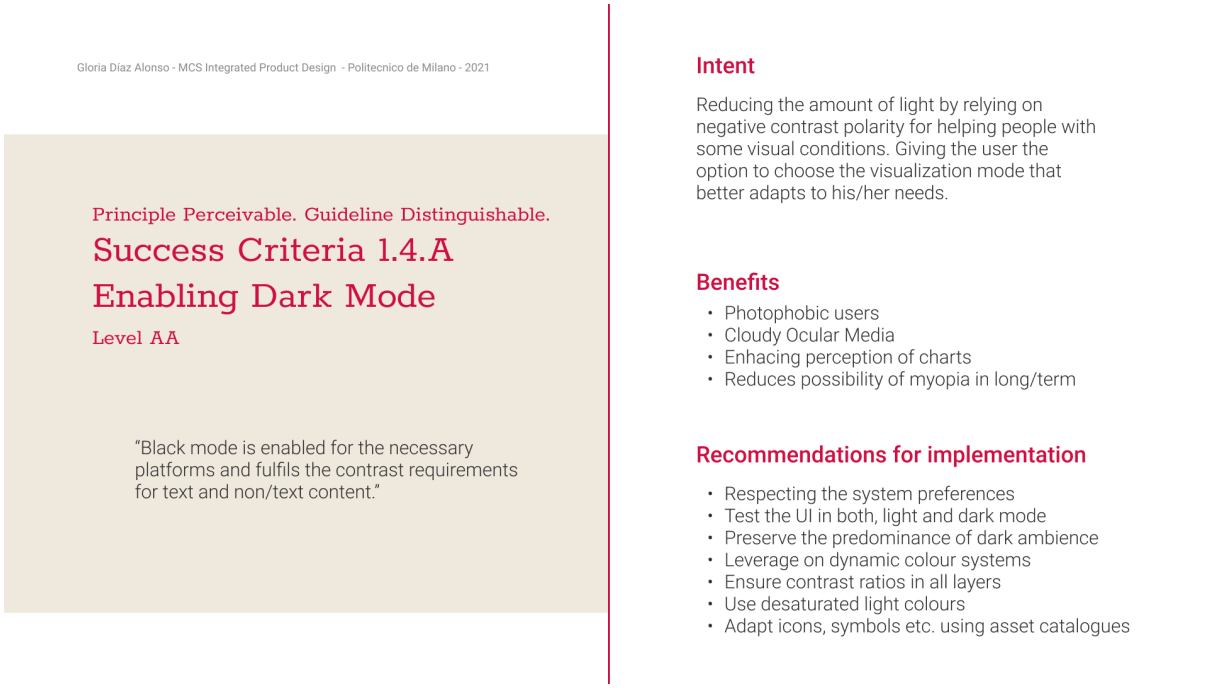

Figure A.11. Slide for expert presentation: SC Enabling Dark Mode.

Alejandro Moledo: I think this one is a very good Criteria and simple to define so it is good.

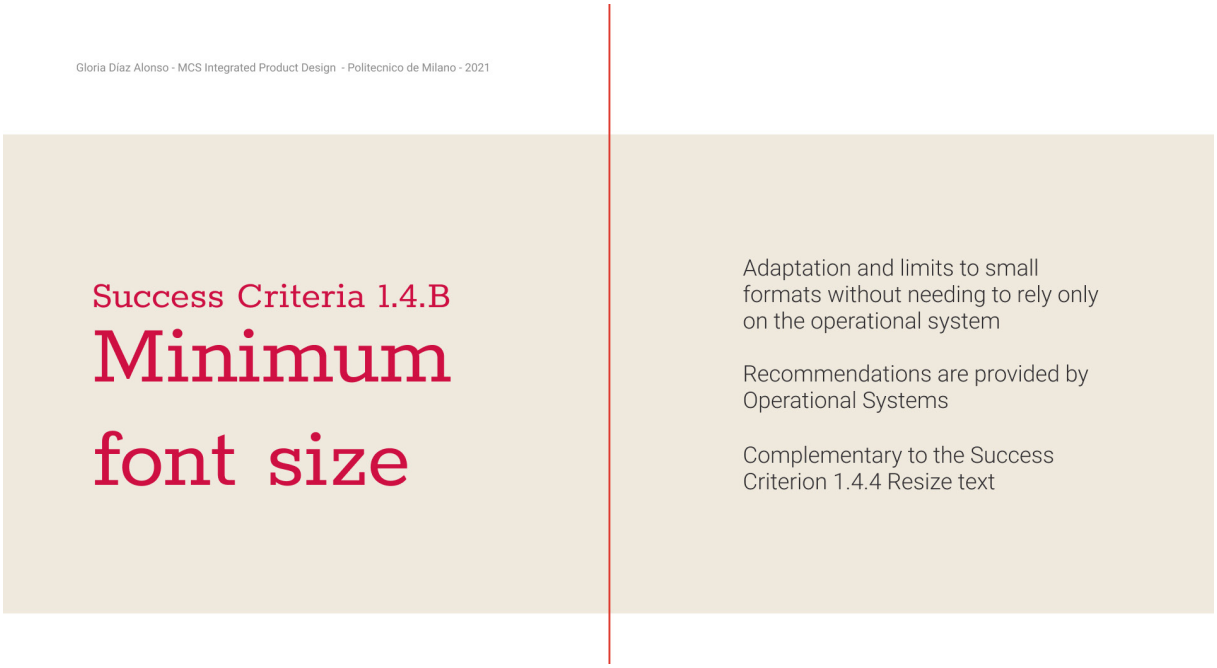

Figure A.8. Slide for expert presentation: Justification of Minimum font size

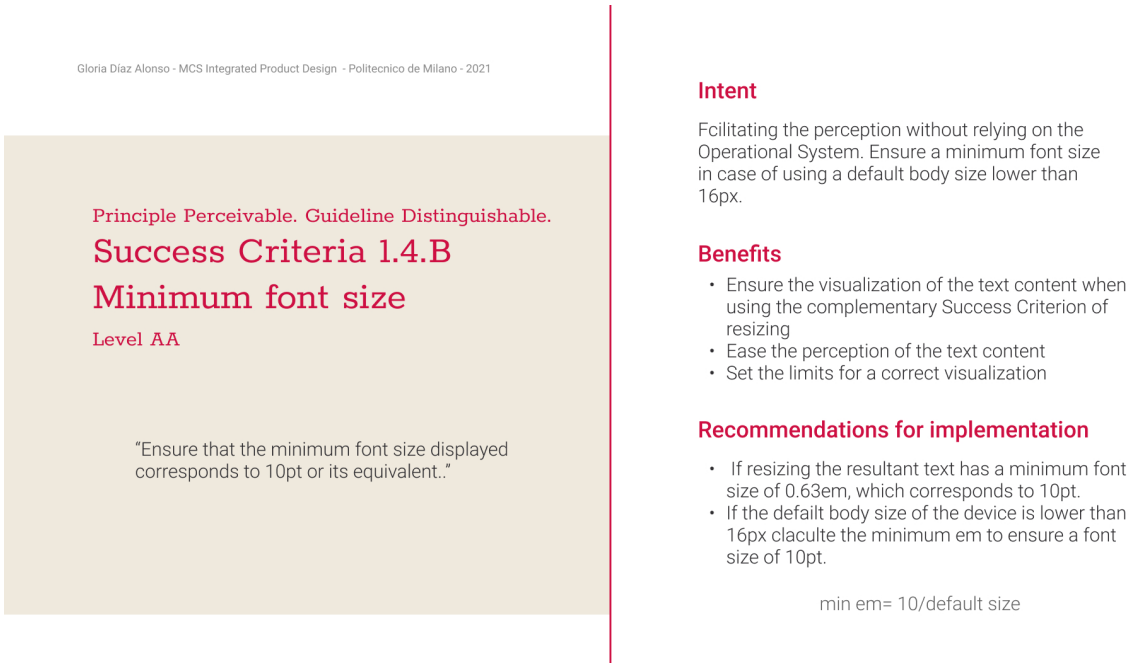

Figure A.12. Slide for expert presentation: SC Minimum font size.

Alejandro Moledo: So does it adapt to smaller screens?

Gloria Díaz: Yes, I was not 100% sure about this limitation because for example smartwatches are considered Mobile devices and they have a very small screen size, so a font size of 10pt might be too small. So it is proportionate but I am also including an absolute limit.

Alejandro Moledo: Okay, sounds good.

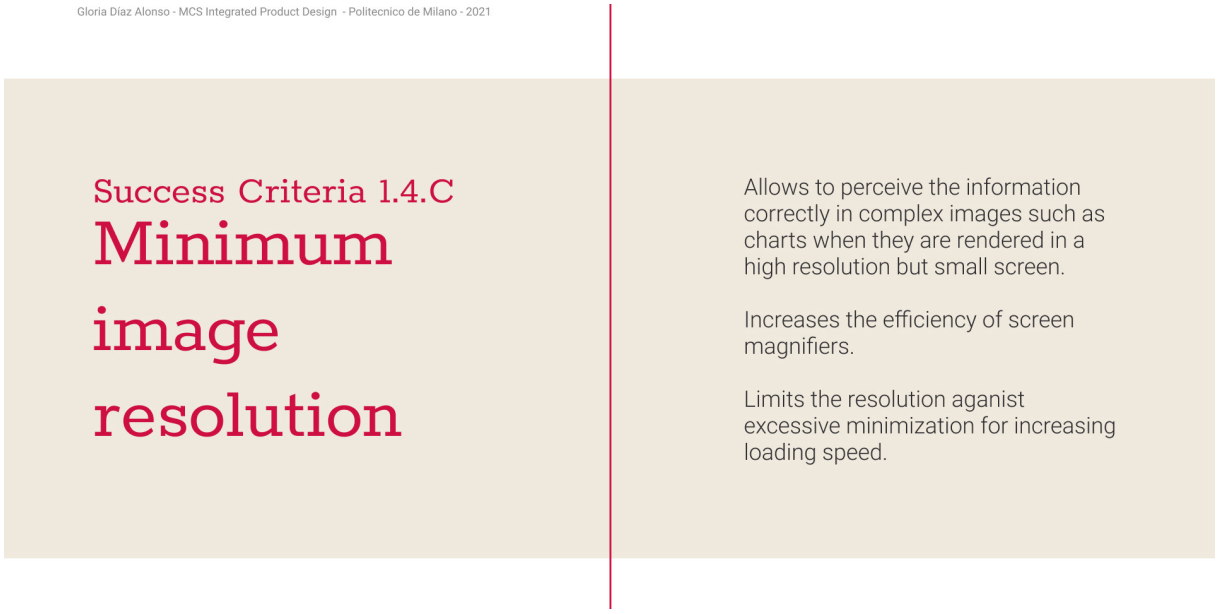

Figure A.9. Slide for expert presentation: Justification of Minimum image resolution.

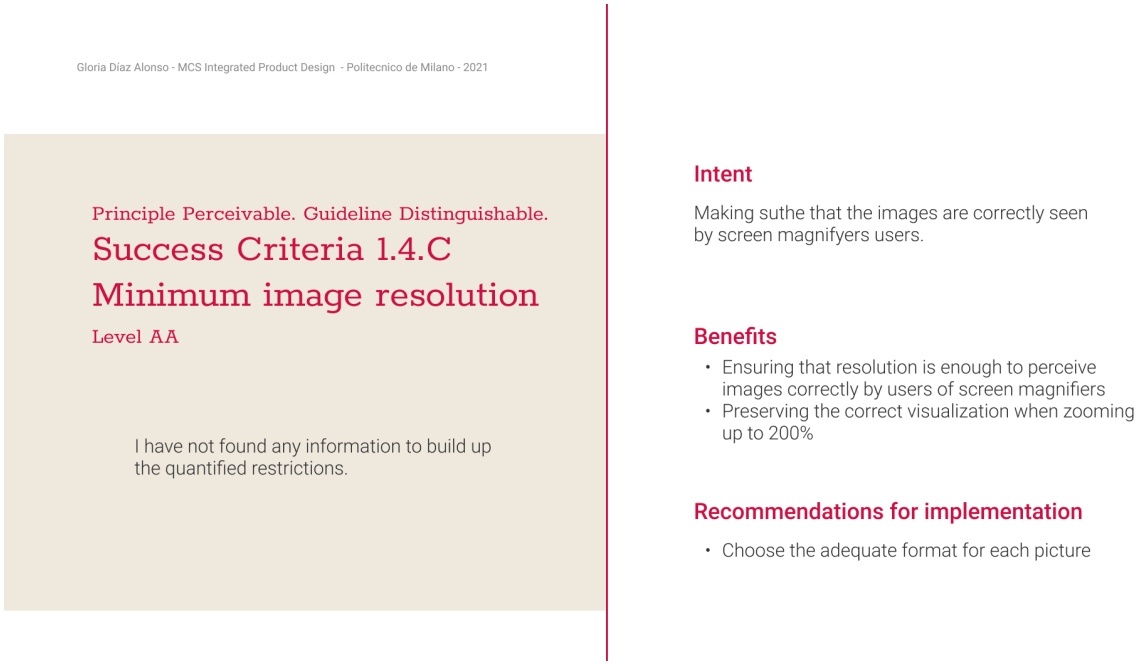

Figure A.13. Slide for expert presentation: SC Minimum image resolution.

Gloria Díaz: I am having a lot of struggles to define this Criterion. I was thinking of something like the minimum image resolution should be at least two times the size at what it would be displayed to safeguard its visualization with 200% zoom. But this would mean that in the case of having a background image covering the full screen that will require a really high quality that might slow down the loading speed, being inconvenient. In addition, I have not found any reference to justify a possible quantified definition of the limits as a backup.

Alejandro Moledo: In this case, you should specify that it would apply to images conveying meaning and not to decorative ones. But I cannot provide you with any reference on where to find them, but I am sure there must be something.

Gloria Díaz: I found some information on how to organize the images and programme the web pages using a markup language to load the images which size is more adequated to the device in use by having different sources for the different breakpoints, but nothing specifying the minimum resolution needed.

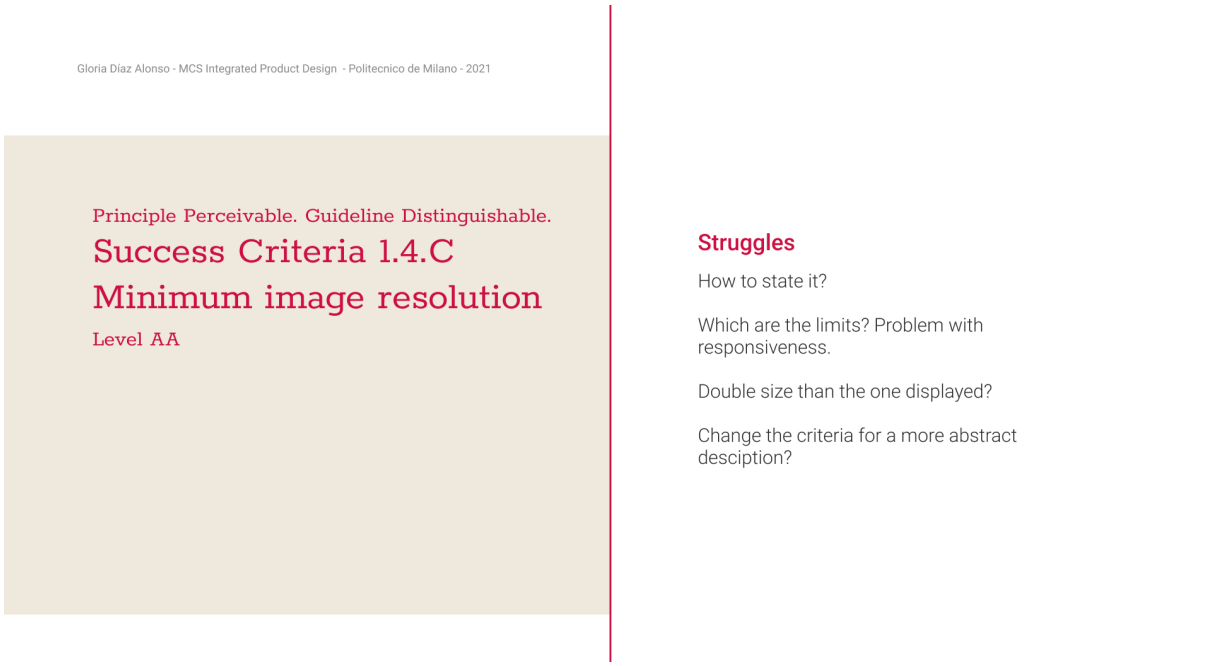

Figure A.14. Slide for expert presentation: Struggles about Minimum image resolution

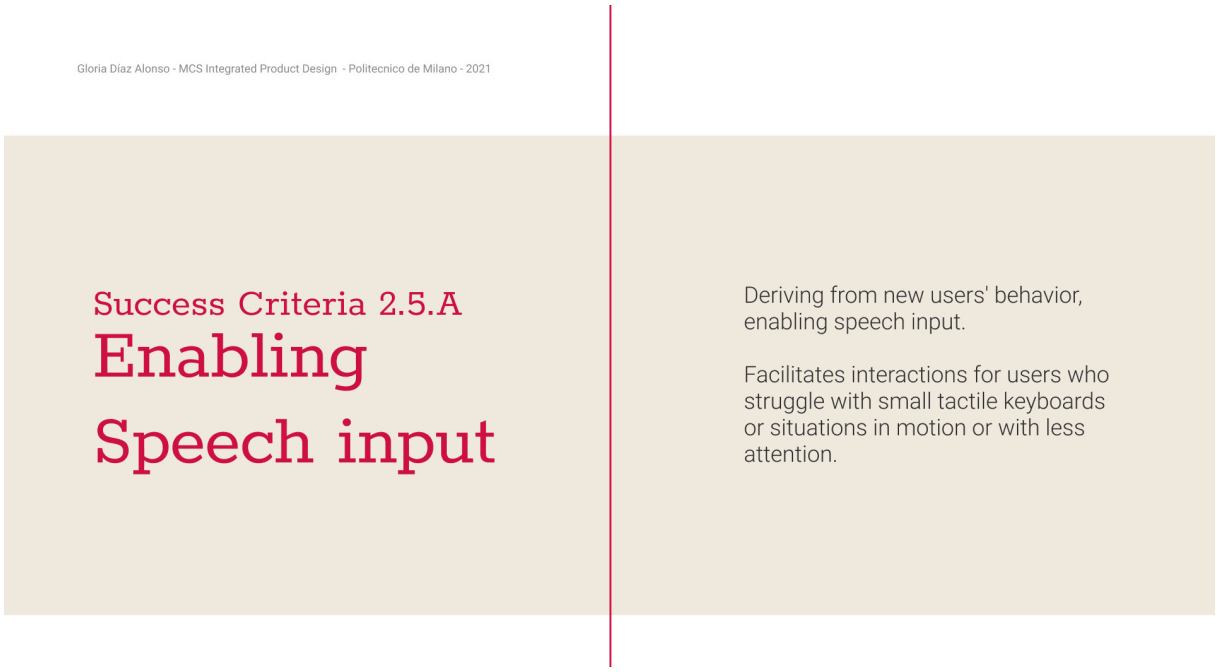

Figure A.10. Slide for expert presentation: Justification of enabling speech input.

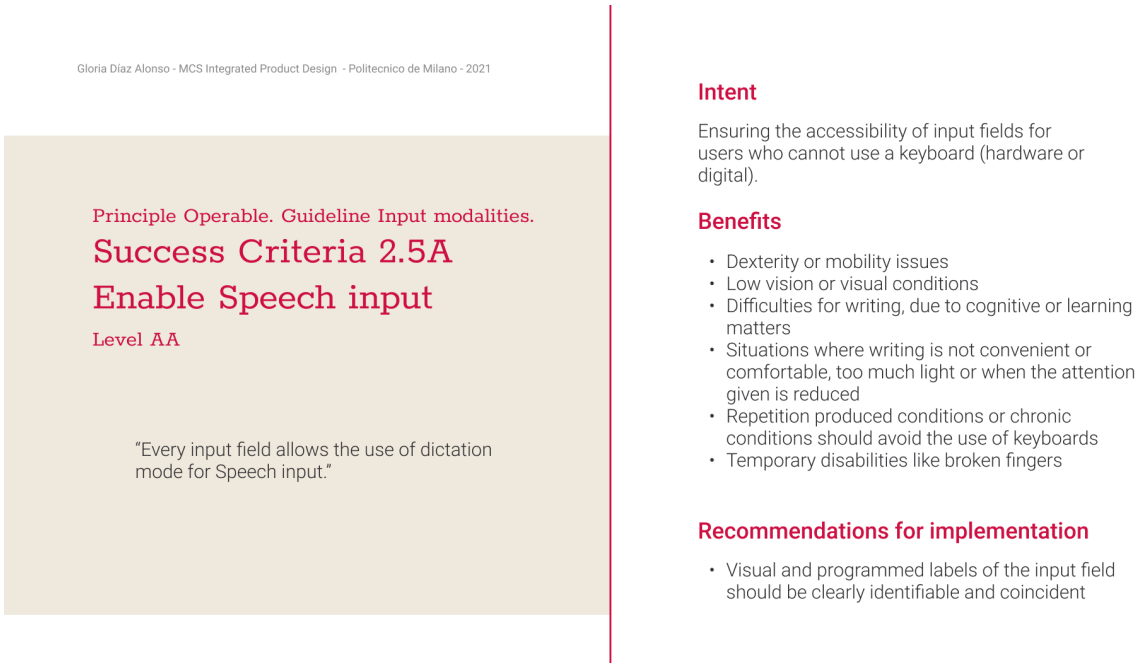

Figure A.15. Slide for expert presentation: SC Enable speech input

Alejandro Moledo: The Criteria enabling Speech Input is definitely relevant and useful. I think for some of the Criteria you are proposing you can find a strong relationship between the Operating System by itself and the User-Agent. Are you considering the implementation of these Criteria on top of the already existing WCAG or the inclusion of a new specific section for Mobile accessibility?

Gloria Díaz: I came up with the because WCAG are not directly addressing Mobile accessibility right now and the specific characteristics they have. They are planning on paying them more attention in the future versions, 2.0 and 3.0, and I think that Mobile accessibility goes further than web content and that new Criterias stated for web content can have a great impact on native apps and mobile accessibility in general.

Alejandro Moledo: Yes, for example, the Dark mode can be implemented in the Operating System and in a different way in the content. I think they are very good suggestions but that they might be related more with the User-Agent and the Operating System than with the Content, speaking of the close functionality we mentioned before.

Gloria Díaz: Sure. The majority of the Operative Systems are already providing these technologies to the user, you can normally set your mobile phone or your browser on Dark mode, but still the app or the web

page to respect those settings and adapt the design to them. If the text is set on the default colour it will easily adapt itself to both modes, but if it is set fixed in green even if the User-Agent allows the change the design of the content won't.

Alejandro Moledo: You should consider the transition of this Success Criteria for WCAG and also for UAAG having a larger impact.

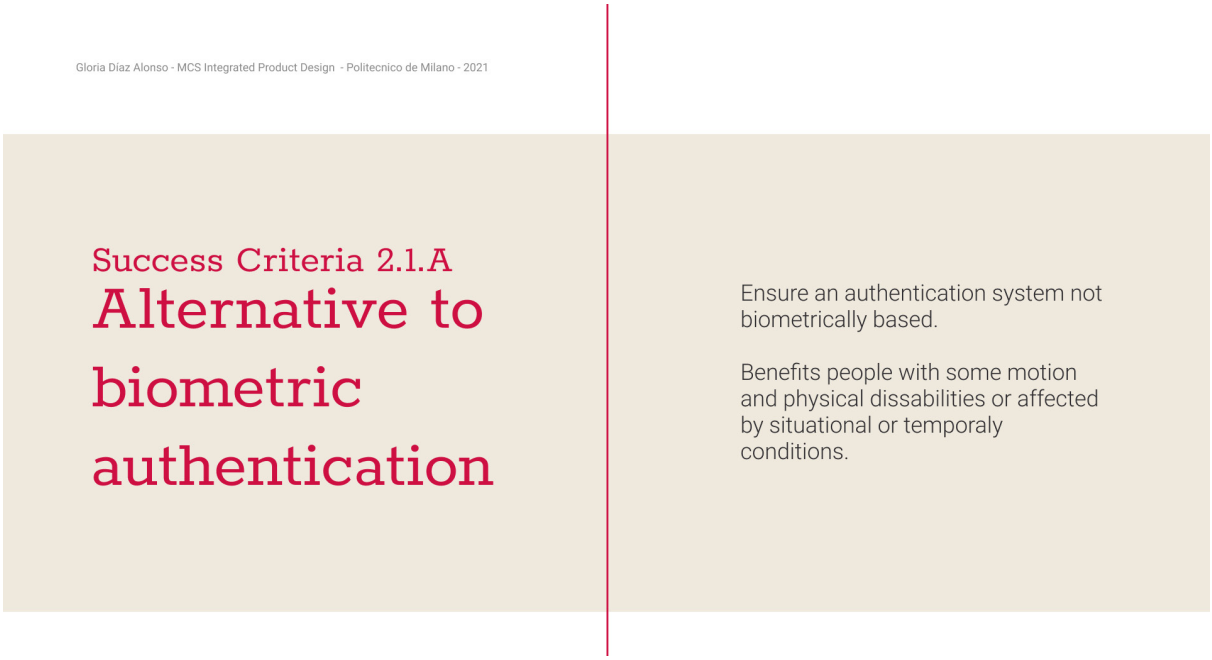

Figure A.16. Slide for expert presentation: Justification of Alternative to biometric authentication.

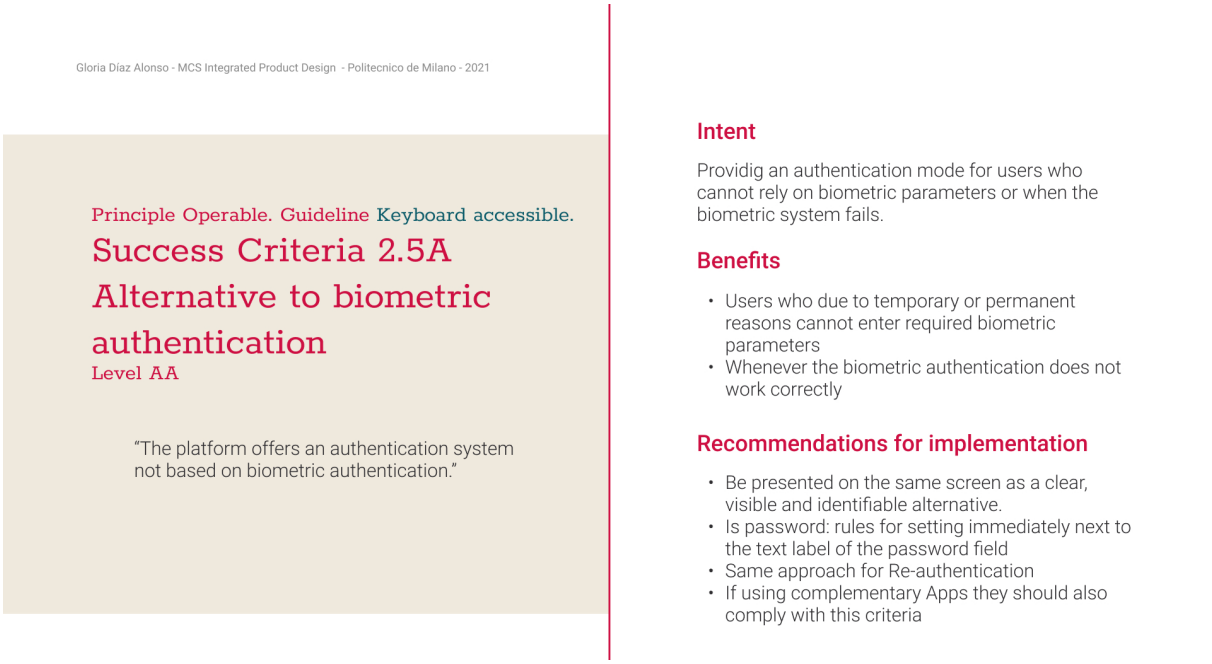

Figure A.17. Slide for expert presentation: SC Alternative to biometric authentication.

Alejandro Moledo: This Criterion is correct and I believe it is also addressed in the EN 301 549 v3.2.1 Standard.

Gloria Díaz: Yes, it is. However, I was having some doubts about if it should be proposed as part of the "Keyboard accessibility" guideline or rather as part of "Input modalities". What do you think about it?

Alejandro Moledo: Umm I am not sure about it. I think it could maybe fit better in input modalities. Maybe you can check the European Standard to see if we say something useful there.

You should probably consider Privacy in the benefits.

Gloria Díaz: Do you have any further comments or feedback on the Success Criteria?

Alejandro Moledo: No, I don't have more to add rather than the consideration of impact also in the UAAG of some of the Criteria, since apps and devices are using for example biometric authentication more and more frequently.

CHECKING TABLE IN ANNEX C

Alejandro Moledo: On the biometric Criterion, you should definitely add some more, without hearing, limited hearing, limited vision and cognitive and learning. It depends on the type of data you are requiring, but you should consider it all.

OTHER QUESTIONS

Gloria Díaz: Further than Mobile devices, what would be the future lines for development on WCAG? Have virtual/mixed/augmented reality been considered?

Alejandro Moledo: Yes, we looked into this, we published a report on emerging technologies called Plug and Pray where we also talked about reality technologies and AI and it is very interesting because there is not

much literature on the accessibility of these technologies. I know a couple of European funded projects looking into this but still, it is not something set in stone or on Standards but for sure they will have an impact on future guidelines. The accessibility opportunities are huge. We could even think about using AI to automatically convert a not accessible website into accessible ones. We see the opportunities but also the risks of further discrimination towards people with disabilities. I believe that at some point WCAG will look at it and the community will set the accessibility requirements for them. We first need those technologies like immersive reality to become more and more common and then the stakeholders will come together for creating some agreements (such as if the captions or the narration for people with visual impairments will follow the view). There are some open questions that need to be answered before. We have the universal design principles and the functional performance categories to use as a baseline.

Gloria Díaz: What might be the perspective of WCAG on Mobile accessibility on version 3.0?

Alejandro Moledo: To be honest I am not following the discussion that closely but I believe they will move towards a more comprehensive approach, maybe something more similar to what you presented, which also has an impact on the User-Agent and the Operational System rather than only on the Content.

19/08/21
Byrne Haber

Sheri Byrne Haber is an accessibility expert currently working for MVWare. As part of her career she was Senior Manager on Global Accessibility for Mc Donald's Corporation and of course as part of the W3C committee. She has immense experience in the practical application of WCAG guidelines and the impact on the different functional performance criteria which, together with her experience as an analyst on accessibility gives her a precise perspective on the definition of the criteria, their impact and limitations.

Figure A.1. Slide for expert presentation: aim of the thesis.

Figure A.4. Slide for expert presentation: characteristics of mobile devices

Sheri Byrne-Haber: The one thing you are missing here is Bluetooth, you can use it for connecting keyboards, or hearing aids, there are lots of assistive technologies that do not need to be built in, you can just connect it to Bluetooth.

Gloria Díaz: But wouldn't Bluetooth also be suitable for desktop devices?

Sheri Byrne-Haber: No. Well, I guess it does, but it is way more common to use it on mobile devices than on desktop because on mobile devices you are walking around with them so it is always with you while on desktop devices you might only use it to connect some noise-cancelling headphones or so.

Gloria Díaz: Another expert recommended I add "close functionality" meaning that the accessibility features are built-in and it is not that easy to include the assistive technology on them.

Sheri Byrne-Haber: Umm, it depends. iPhone is very consistent but Android is very inconsistent. I would say if you want to call it a characteristic it has to be more generic, there is a large number of differences between iOs and Android in terms of accessibility. Android has Nokia, Google, Sony, and they all introduce different things. The Kindle is even considered an Android device but Amazon created their own version of TalkBack so I think it is a significant difference.

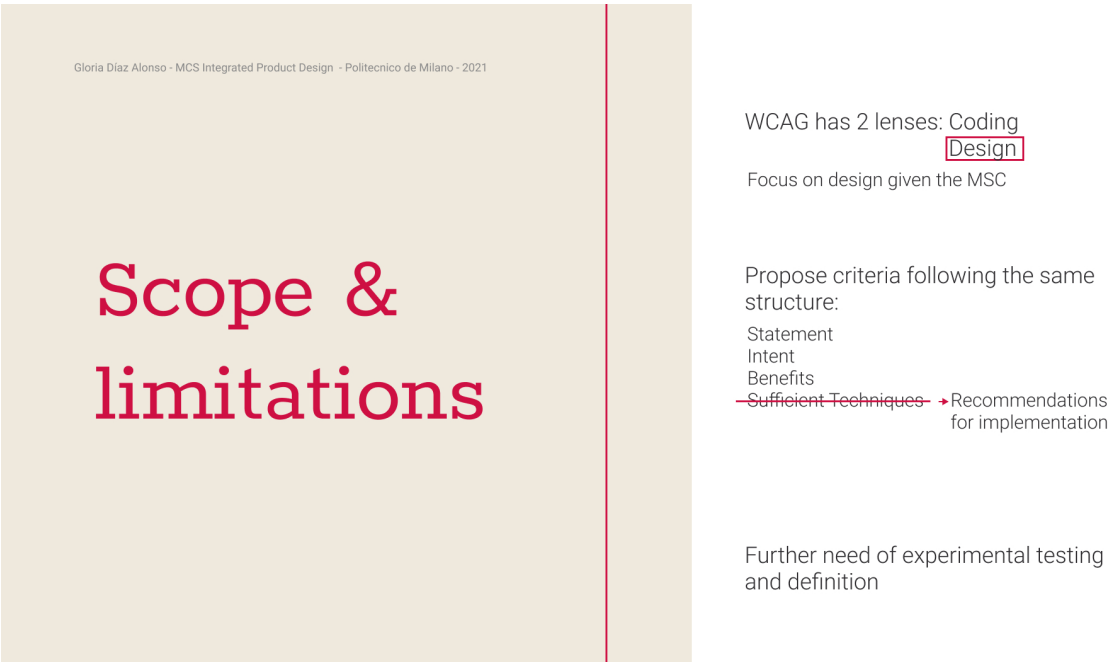

Figure A.6. Slide for expert presentation: scope and limitations of the thesis

Figure A.7. Slide for expert presentation: Justification of Enabling Dark Mode

Sheri Byrne-Haber: I absolutely despise dark mode. I have glaucoma and people with glaucoma has a halo effect when we have a dark mode, it also decreases the legibility of long text so people with dyslexia struggle a lot. It is also harder to make accessible because the link text and the visited link text colours are normally blue and red and on a dark background it is difficult to make them comply with the contrast regulation. Nobody is ever allowed to release dark mode only. The light mode must be the default but if the user wants to use dark mode they can use that and if it is behind the login we require that the software remember that the person requested dark mode so next time they use the software it is automatically done so they don't have to switch again.

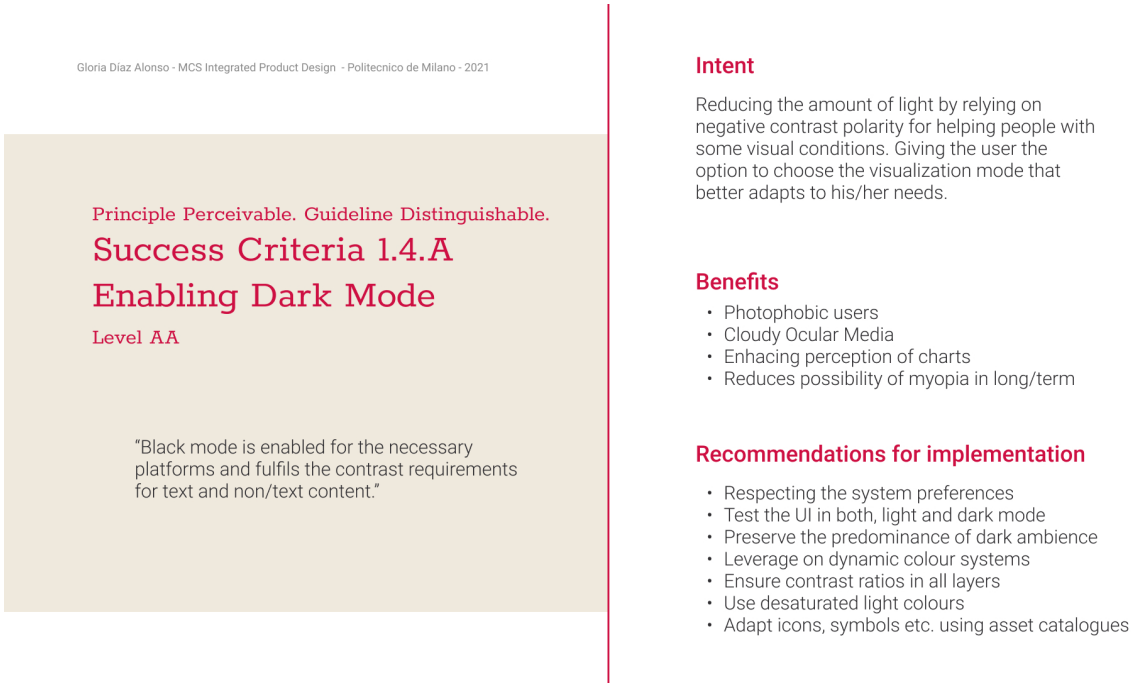

Figure A.11. Slide for expert presentation: SC Enabling Dark Mode.

Sheri Byrne-Haber: Americans are trying to always call it "dark mode". I wrote an article on the dark mode that was probably in the top five of my articles. The other negative point is for people who are colour blind. If you are using red and green on the dark mode it is very hard to see. I think the net is that more people like it than hate it but there is a lot of people who hate it.

You also should add that the keyboard focus indicators and the activatable icons also meet the colour contrast against dark mode.

Figure 4. Slide for expert presentation: Justification of Minimum font size

Sheri Byrne-Haber: I tried to focus on the guidelines of the Operating Systems but for smartwatches maybe 10pt was already too big.

That is why of the reasons why we have avoided this criterion and decided to focus on colour contrast and resizing. In the coming WCAG 3.0, the colour contrast is getting more demanding as the font size gets smaller and also the magnification rules. The assumption is that if you have a tiny font but the magnifications rules are followed you should be able to set the font at a comfortable size for you. The measurement that we use for touch target size is CSSpx, every CSS pixel is 1:96 inches so size doesn't vary with other resolutions or anything like that so if you want to be consistent with that you should probably consider having a different limit for serif fonts and sans serif fonts, because san serif fonts are way easier to read so they could be a 9pt while serif fonts might need to be an 11. There is some research online with people with dyslexia and their reading speed on sans serif fonts. I don't think that there is anything directly on point but if you search for those it should be useful and otherwise let me know and I will search through my articles.

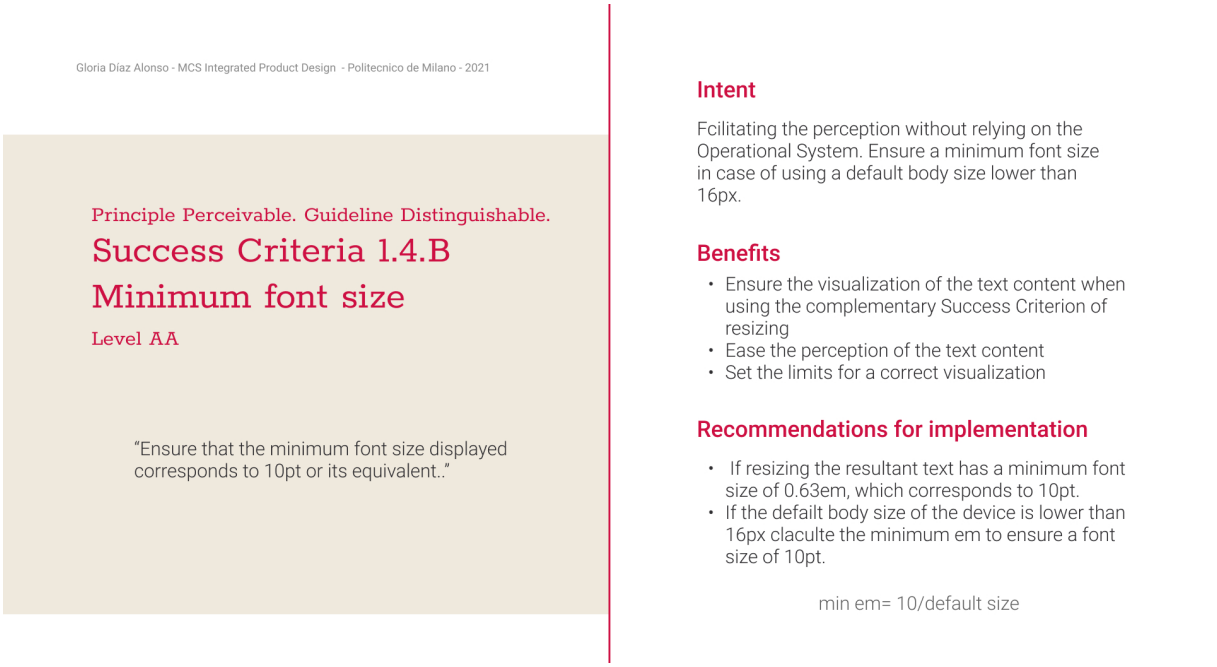

Figure A.12. Slide for expert presentation: SC Minimum font size.

Sheri Byrne-Haber: I think that the only bad side of this one is the one you already pointed out, smartwatches where the minimum size might be problematic.

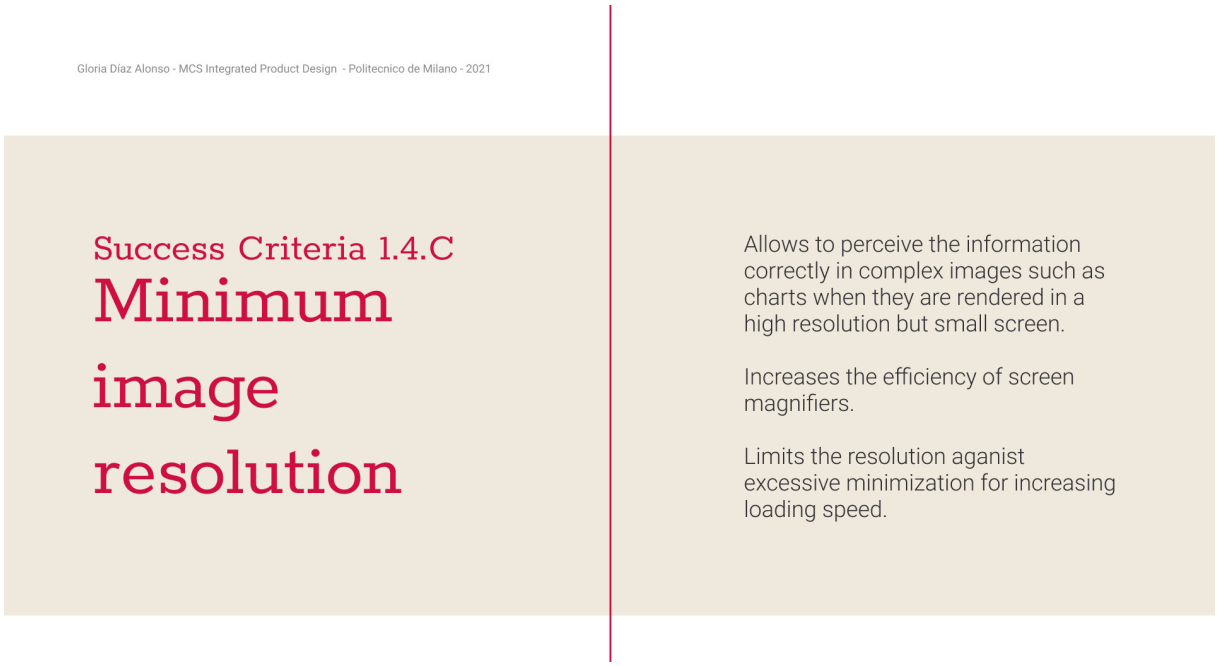

Figure A.9. Slide for expert presentation: Justification of Minimum image resolution.

Sheri Byrne-Haber: In minimum image resolution, there is another rule I am sure that you are familiar with it which is not to embed meaning text in images. The minimum resolution is the most important at that point, where there is text and you still wanna be able to read it.

Gloria Díaz: Yes and also in charts.

Sheri Byrne-Haber: Yes, you are right! It is not a bad idea, you just need to keep in mind that if the images are not going larger is because larger resolution requires longer loading time, you get a performance hit. Also, they can create a less predictable reflow.

Gloria Díaz: In some cases, they define three different sources for images according to the breakpoints so in that case, they make sure that if you are seeing a small image you are not loading a super quality one.

Sheri Byrne-Haber: Maybe it could be something similar to what websites have for changing the font quickly, you know, this little "A" and big "A" on top. You could have a picture next to the graph to switch, so you have the low-resolution load by default but if you activate the icon you will have a higher resolution.

Gloria Díaz: Yes because I was thinking of something like "for each image the resolution needs to be at least twice the size at what it will be displayed" or something similar but that would definitely affect the loading speed.

Sheri Byrne-Haber: Right, you understand the limitations.

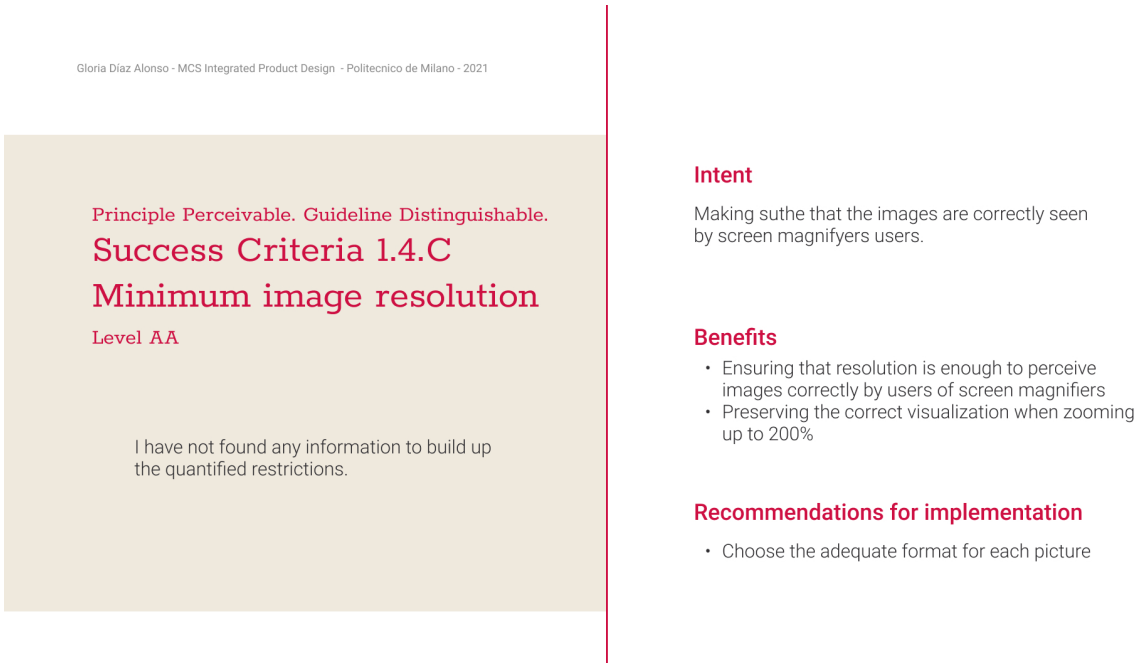

Figure A.13. Slide for expert presentation: SC Minimum image resolution.

Sheri Byrne-Haber: I was confused about this one because it is supposed to be enabled all the time.

Gloria Díaz: Yeah I created this one with the help of other experts focusing on the cases where the system provides a customized keyboard overriding the default one. Like in the case of banks changing the position of the numbers for increasing security.

Sheri Byrne-Haber: But that is a keyboard shortcut violation, they shouldn't be doing that. The reason for a criterion should not be that someone is screwing up another one. I am pretty sure that if the accessible name and keyboard shortcut correctly speech input should work. One of the rules is don't remap the keys to something that the user does not expect. The really important one is the accessible name one because if you rename the fields like "field 1" "field 2" and "field 3" when I am a speech input user I need to know what is the address.
You won't see any other criterion where you specifically address the enabling of a specific assistive technology, that is not how W3C states them.

Gloria Díaz: Ok but I believe that there is already a success criterion defending that the programmed labels need to have the same name as the display ones right?

Sheri Byrne-Haber: Yes yes, there is.

Gloria Díaz: So this criterion would not fit in the catalogue of WCAG then?

Sheri Byrne-Haber: I don't think so.

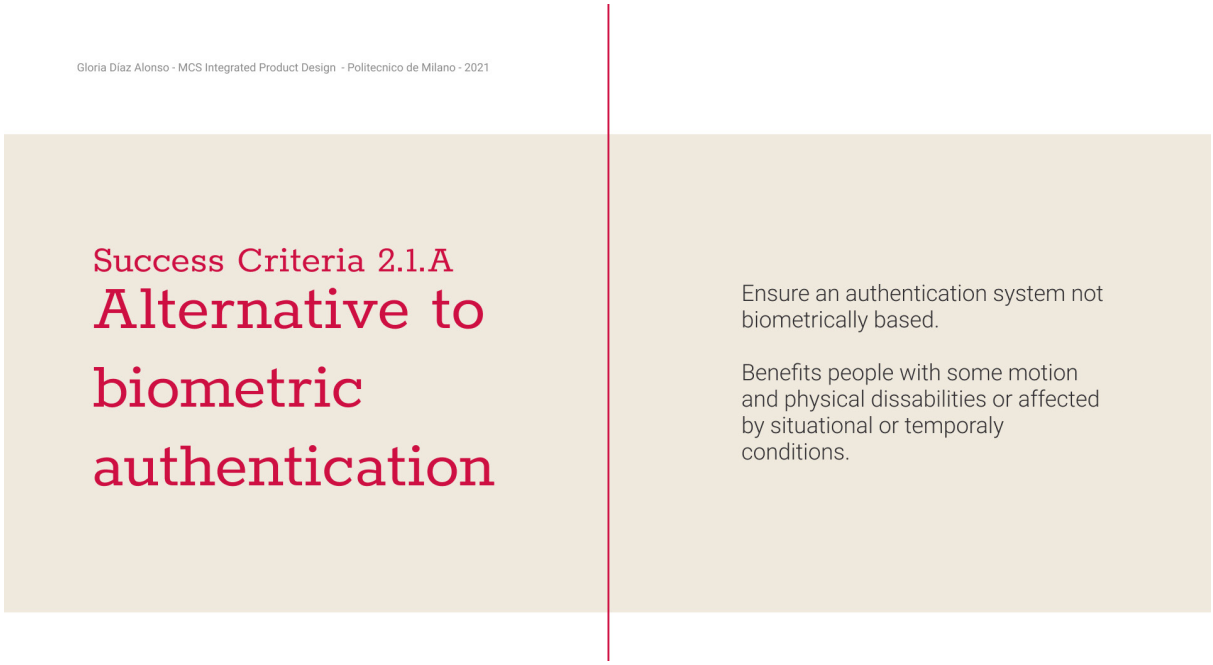

Figure A.16. Slide for expert presentation: Justification of Alternative to biometric authentication.

Sheri Byrne-Haber: Yes, this one is coming in November, it is already being implemented, It will be part of WCAG 2.0 and it is called "Accessible authentication".

Gloria Díaz: SWhat guideline does it belong to, because I was not sure if it would be input modality or keyboard accessible?

Sheri Byrne-Haber: Let me check, it is 3.3.7 so it is part of a new one called "Input assistance" it gripes with the errors. I was not super involved with this one. Instead of proposing as a separated criterion, I would propose it as an expansion of 3.3.7. Accessible authentication means that you need to provide at least one way other than remembering a password

for getting into the system, but the one way could be biometric, so what you wanna do is that if one way is biometric then you have to provide two ways. I have a friend who has no fingers so he is sensitive to biometric authentication and my middle daughter was born without ears so she has the same problem with facial ID because it uses the ears to decide whether someone has or not a face. So this is something I would do, I would propose a modification to 3.3.7.

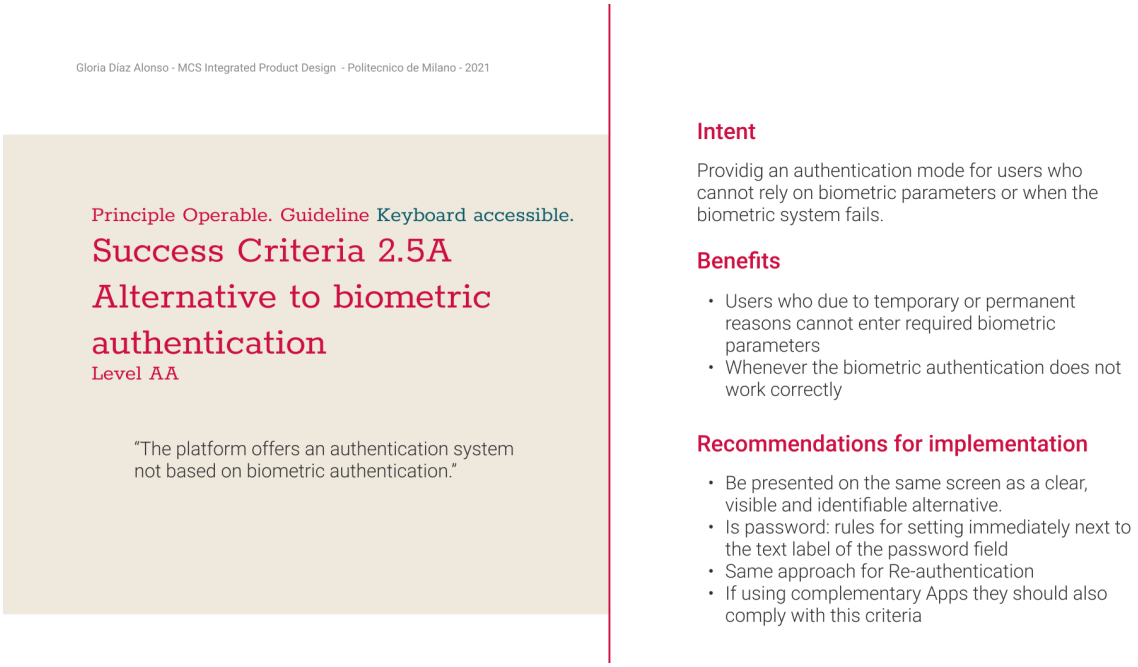

Figure A.17. Slide for expert presentation: SC Alternative to biometric authentication.

Sheri Byrne-Haber: As part of the recommendation, the system should remember the option that the user chose. My daughter who was born without ears is deaf and when she was little she was very mad that Amazon didn't remember that she was deaf. Her aggravation was that she would go to Amazon to look for song lyrics so she could understand what her friends were listening into music, and every time she will need to turn close captioning on, and it absolutely drove her crazy. The whole remembering is making it better, it helps to save time and it eliminates what we call micro-interactions.

CHECKING TABLE IN ANNEX C

Sheri Byrne-Haber: Understand that the proposed functional criteria for 3.0 are way longer than this one so you should use that one. I would maybe change this table to show that works for 2.0 and for the 3.0 I would put all functional criteria and just mark which ones are 2.0 and which ones are 3.0. 3.0 has a lot to do with neurodiversity and it is very good to understand how your criteria work with them. For dark mode, it might help with some, same with the font size and the resolution.

OTHER QUESTIONS

Gloria Díaz: Further than Mobile devices, what would be the future lines for development on WCAG? Have virtual/mixed/augmented reality been considered?

Sheri Byrne-Haber: We have an entire note that already has been released un VR nad XR so I will send you the link. I am working on that in my company because we are starting to use VR for training on security and compliance to make it more appealing. I am working on accessible training on the expense report.

Gloria Díaz: What might be the perspective of WCAG on Mobile accessibility on version 3.0?

Sheri Byrne-Haber: Other than mobile devices in terms of the future WCAG has always tried to keep guidelines device-independent, there are other two criteria specifically for mobile and they are orientation and shaking. We only do mobile-specific when we have to.

Annex B:

UniCredit Omnichannel accessibility audit

In order to fully understand the structure and content of WCAG for performing the correspondent critique and spotting opportunities to improve Mobile accessibility, we relied on the practical analysis of the guidelines in an existing Design System. The execution of my internship in the company Fifth Beat carried out at the same time as my thesis provided me with the opportunity to perform an accessibility audit as one of the projects I was assigned to. The platform chosen for executing the accessibility audit is one of the new Design Systems designed by the company Unicredit, UniCredit Omnichannel. Two of the branches of the company are developing different Design Systems that will then be merged and aiming to comply with the WCAG standard they are asked to spot the main accessibility issues and evaluate the level of compliance and Criteria passed for the Design System. The performance of the named accessibility audit provided us with the understanding of the practical application of the success criteria and the evaluation, tools needed and challenges that they entail. It gave us a deep perspective of new possible action points and offered a highly valuable insight into the working principle of WCAG.

Some of the cases spotted during the audit have been used to illustrate possible problems or cases on the proposal of the new success criteria.

The audit consisted of the analysis of the two documents that defined the Omnichannel Design System, "Foundation" and "Components" and the prototypes for responsive web provided by the company. The information provided in the present Annex corresponds with a third document developed for the audit that gathers the main problems found in the Foundation and Components, as well as a detailed analysis of the status of each success criteria through the prototypes provided.

The analysis of the prototypes has been done using the subsequent tools:

- Automatic checkers for WCAG
  - Wave
  - Axe
  - Siteimprove
  - Lighthouse
  - Colour Contrast Checker (CCA)
- Manual keyboard control analysis
- Screenreader VoiceOver
- Disabilities simulators
  - Funkify
  - SEE

The document is structured following these points:

1. **Executive summary.** It contains the most relevant issues found in the Foundation, Components, Prototypes, the provided Code repository and the comparison with Bricks Design System.
2. **Audit of success criteria Level A.** Presenting the status as: Pass, Not applicable, Fail, Warning (small issues found) and To be Check (by the developers). It includes a detailed explanation with examples of all the success criteria evaluated as "Fail" or "Warning" and a short comment provided by the developers on the difficulty of solving it.
3. **Audit of success criteria Level AAA.** Same structure and content than for Level A.
4. **To keep in mind from Level AAA.** Stating those level AAA Criteria

that might be interesting to keep in mind for the development of the system.

5. **Appreciations using a Screen reader.** Highlighting issues that do not necessarily relate directly to a success criterion but that entails an accessibility issue for screen readers users.
6. **Looking for solutions to the Foundation issues in Bricks (not included).** Unicredit has developed in parallel another Design System called Bricks. This point takes the main issues found in the Foundation and Components of Omnichannel and checks how Bricks addresses them to see if their solution could be reused or if it is a shared issue that needs a new solution. Since this last point is an internal search for solutions within the existing resources inside the company rather than helping to understand the guidelines it has not been included in this Annex.

1. Executive summary

Foundation

In general, the foundation is well-stated for complying with accessibility guidelines. However, there are some critical problems that have been identified:

- **Colour.** There is a big problem with the colour code since the Accent colour does not comply with the guidelines. Colour palette should be reviewed and arranged for complying with the criteria for both, text and non-text content. The warning colour is not compliant either.
- **Focus.** In addition, the focus appearance considered is in many cases not clear enough, needing to be rethought (this is, nevertheless, a subjective. appreciation).
- **Reflow.** Special attention should be given to the re-flow and the grids provided for Mobile devices since there is no grid presented for the minimum required dimension required by guideline 1.4.10 Reflow.

Components

- **Colour.** Since they follow the guidelines the main problem is the colour contrast.

- **Focus.** The focus is many times just state by a change on the colour, the contrast between the colours used is not enough so sometimes it is difficult to recognize if the element has been focused or not. The colour used to indicate "focus" on dropdown menus and other elements do not have enough contrast with the background so it cannot be used alone as an indicator.

Prototypes

- **Colour.** Problems with the contrast derived from the foundation.
- **Focus / keyboard control.** In addition to the colour issues:
  - Some elements are not focusable when using keyboard
  - The focus order is not always logical since it skips some elements or does not react correctly to pop-ups
  - It is difficult to identify the elements that are focused
- **Structure.**
  - The structure of the pages lacks some important fields such as <h1>
  - The heading structure is respected visually but not programmatically, all the headings are programmed as <h2>
- **Reflow.** The re-flow should be refined for not having interferences between information and respect the correct visualization on the minimum set dimensions
- **ARIA.**
  - Some elements such as titles are missing the correspondent ARIA labels or attributes
  - The programmed label should be coincident with the one visually displayed
  - The states of the controls should all be programmatically defined

Many of the problems come derived from the foundation, mainly due to the colours. The issues related to coding have been checked with one of the developers and the majority of them are easily solvable. However, some depend on the programming approach so a deeper change would be needed.

Comparison with Bricks

After performing the analysis and identifying the main problems in the foundation and components we made a comparison with the elements defined on Bricks to see if they were providing a satisfying solution to the problems by combining the Design systems. In case of the problem is not being solved by any of the design systems, we highlight the need of finding a new solution. Solutions are still needed for the correct design of the following elements:

- Focus colours
- Warning colour
- Progress indicator
- Tabs

Code repository

Storyboard, the tool chosen for creating a repository of the components (visually and programmatically) offers an automatic accessibility checker. The developer said that the ARIA attributes and labels can be determined already in the storyboard, while some other languages that depend on the markup language cannot. The main issue is that definition of all the elements according to the accessibility guidelines was not a requirement set in the first place so the workload derived from that programming is not covered in the budget.

2. Audit of SC level A

Here you can find the. list of all the Success Criteria of WCAG 2.1 for Level of Conformance A. The colour code explains the status of the criterion in relation to the prototypes analyzed.

Please note that those criteria that are not applicable might be due to the state of the prototype, the absence of the relations between screens or the lack of content related (e.g. video content). However, they must be taken into account for further developments.

Warning status means that there are some small issues related to the criterion that should be attended but the general behaviour of the prototypes is compliant.

Those Criteria that have been evaluated as "Warning" or "Fail" are explained in more detail in the following pages.

This document is complementary with the already existing"Foundation" and "Components". In each of them, we can find information and suggestions regarding accessibility for the defined components and key points of the foundation.

Result	Success criterion	Topic
Pass	1.1.1 Non-text content	Understanding images, videos and audios
Not applic.	1.2.1 Audio-only and video-only (prerecorded)	Alternative for understanding should be provided
Not applic.	1.2.2 Captions (Pre-recorded)	Captions provided for pre-recorded audio
Not applic.	1.2.3 Audio description or media alternative (pre-recorded)	Alternative for time-based media
Fail	1.3.1 Info and relationships	Structure is determined programmatically
Fail	1.3.2 Meaningful sequence	Reading sequence programmatically set
Pass	1.3.3 Sensory Characteristics	Information does not only rely on sensorial factors
Pass	1.4.1 Use of colour	Colour is not the only resource used as an indicator
Not applic.	1.4.2 Audio control	Inclusion of control mechanism for audio
Fail	2.1.1 Keyboard	All functionality operable by keyboard
Warning	2.1.2 No keyboard trap	No trap existing and functionality explained
Not applic.	2.1.4 Character key shortcuts	If shortcuts, there is a mechanism to control them
Pass	2.2.1 Timing adjustable	Can be turned off, adjusted or extended
Not applic.	2.2.2 Pause, stop, hide	For moving, blinking, scrolling or auto-refreshing
Not applic.	2.3.1 Three flashes or below threshold	Below 3 times per second or below threshold
Warning	2.4.1 Bypass blocks	Allow to bypass content repeated
Warning	2.4.2 Page title	Title is descriptive and HTML <title> element
Warning	2.4.3 Focus order	Focus order is consistent and meaningful

Pass	2.4.4 Link purpose (in context)	Determined by the text or the context
Not applic.	2.5.1 Pointer gestures	Path-based/multipoint gesture accessed by pointer
Pass	2.5.2 Pointer cancellation	Functions on up-event or can be aborted
Fail	2.5.3 Label in name	Name of levels express the one shown visually
Not applic.	2.5.4 Motion actuation	Functions by motion can be on single pointer
Pass	3.1.1 Language of pages	Can be programmatically determined
Warning	3.2.1 On focus	Info does not change when receiving focus
Pass	3.2.2 On input	Entering input does not automatically change context
Pass	3.3.1 Error identification	Errors detected are described and identified
Pass	3.3.2 Labels or instructions	Provided when needing input
Pass	4.1.1 Parsing	IDs are unique, no duplicated attributes
To be checked	4.1.2 Name, role, value	Can be programmatically set

Pass Warning Fail To be checked Not applic.

Table B.1. Status of compliance of UniCredit Omnichannel with WCAG level A

1.3.1 Info and relationships Fail

Some ARIA attributes are missing. In the case of headings, they are not identified several times as so by an ARIA attribute and almost all of them are defined on the same level of structure on html. (h2) which makes more difficult the understanding of the structure by screen readers' users.

Make sure that the structure on the. headings are applied, that the elements have an adequate aria attribute and that the pages have a descriptive heading level 1.

All the structural. and interactive. elements should have the ARIA attributes required. Bullet lists for example should be identified.

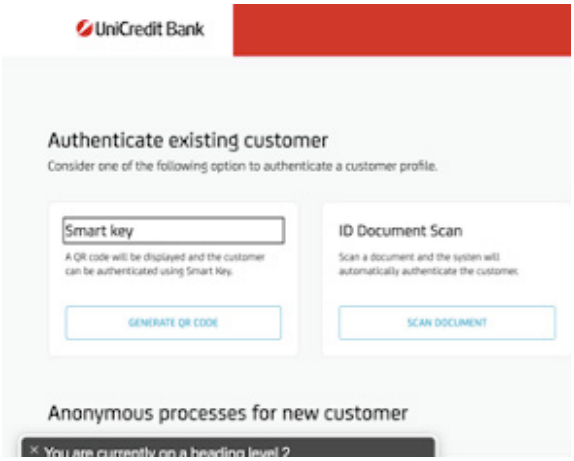

Figure B.1. All headings have the same level <h2> but different visual options.

Developer's comment: Guidelines to follow. Programming approach.

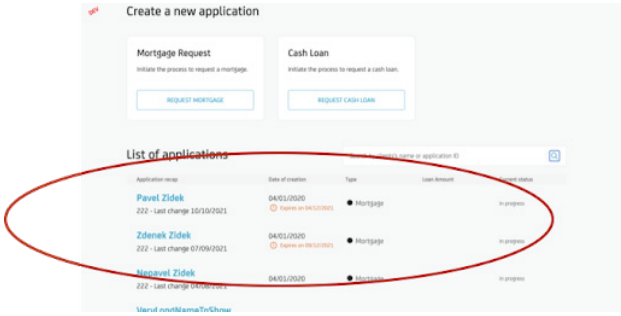

Figure B.2. Part of the main content is not accessible by keyboard

1.3.2 Meaningful sequence

Fail

Not all the functionalities are accessible through the keyboard. As a consequence the. focus sequence is missing important information and interactive elements, missing even the main content in some cases.

The navigation should be done including all the interactive elements, respecting the hierarchy of the layout and the relationships set between them. Language standards should be also taken into account. (in English reading from left to right and from the top to the bottom).

Developer's comment: Easily solvable.

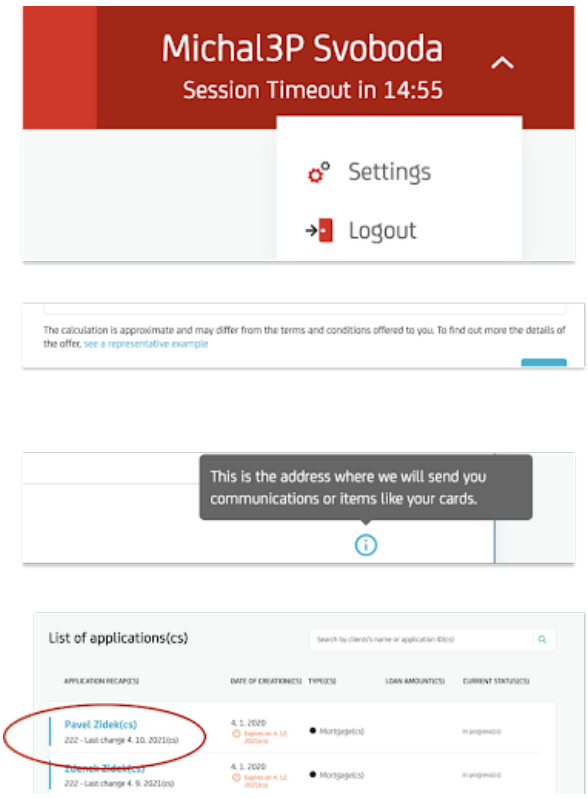

Figure B.3. Personal area, settings, logout, tooltips and some interactive elements are not keyboard accessible.

2.1.1 Keyboard

Fail

The main problem is the access to the personal area or the timing options on the top right corner of some screens.

In many cases, in-text links are not accessible through the keyboard.

In addition, tooltips are not accessible.

Developer's comment: Easily solvable except for the tooltips. Click function should be added.

2.1.2 No Keyboard trap

Warning

Generally, there is no trap but when a pop-up window appears the keyboard is not able to focus on the close icon in the top right corner. In consequence, sometimes you cannot close the window and are trapped.

Figure B.4. “Close” icon on pop-ups cannot be closed.

Developer’s comment: Easily solvable.

2.4.1 Bypass block

Warning

When the content is repeated it can be tedious for screen reader users to navigate since they need to wait for the system to read that info. This can happen with the navigation menu, banners, etc. In this case, a link or button to skip it and go directly to the main content should be available (use markup language for signalizing the main contain). It is recommended to use landmarks for identifying the blocks.

Figure B.5. Example of “Skip” button on W3C webpage.

In this case, given the sample test we have, we cannot evaluate it. But it should be taken into account and suggested to be included.

It should be presented at the beginning of the web.

Developer’s comment: Might depend on the screenreader too. Main content is identified with a markup language.

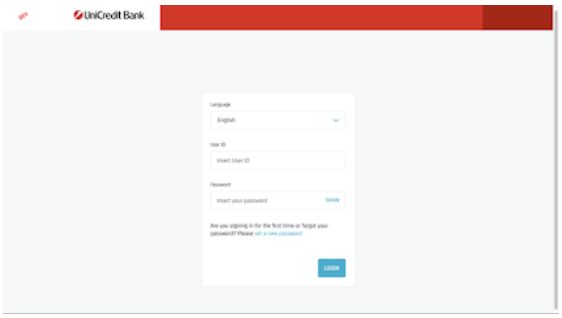

Figure B.6. Login screen without title to identify it.

2.4.2 Page title

Warning

In general, the pages have descriptive titles, except for:

- Login
- Main page

However, the headlines and tile programming structure is not appropriate sometimes.

Developer's comment: Easily solvable.

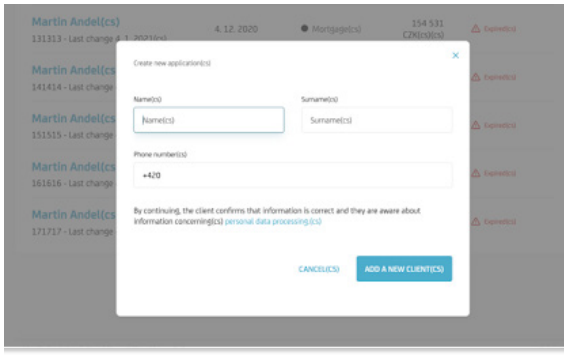

Figure B.7. Pop-up launched.

2.4.3 Focus order

Warning

When navigating and opening a pop up on top of the page the system continues scanning the remaining focusable elements in the original page (bellow the pop up) and then enters the pop-up.

To facilitate the flow and not confuse the user it is better to change the focus order and start in the pop-up window.

Developer's comment: Easily solvable.

Figure B.8. The visual and programmed labels are not coincident.

2.5.3 Label in name

Fail

The name assigned to the label of an input field, button or control while programming should be coincident with the one visually displayed so users who benefit from speech control can interact correctly.

For instance in this case the programmed label is "username" while the text displayed is "User ID".

Developer's comment: Never heard of it before. What about different languages?

3.2.1 On focus

Fail

When a user interfaces component receives focus it does not initiate a change of context. In our case tooltips are only appearing on hover and not on click, which can be difficult for users with dexterity problems.

The steps to follow during the processes are only visible during focus, and they are not accessible through the keyboard.

Developer's comment: Easily solvable.

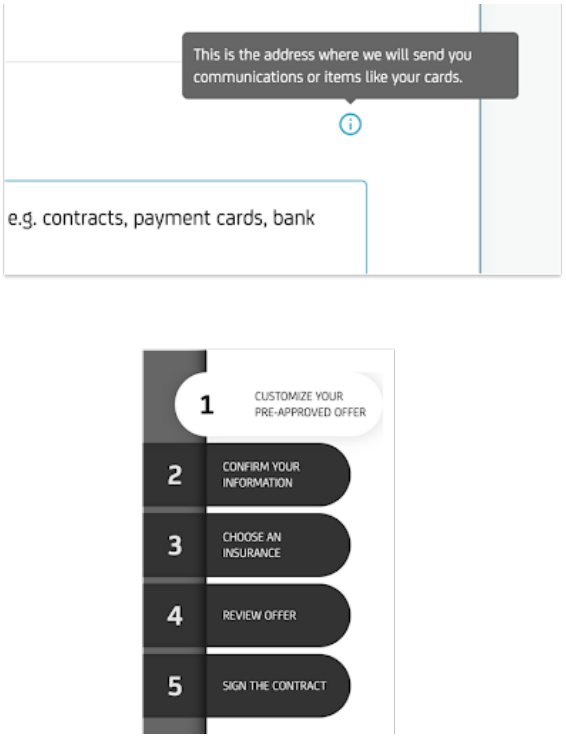

Figure B.9. Tooltips and steppers that change the info on focus.

4.1.2 Name, role, value

To be checked

When a user interfaces component receives focus it does not initiate a change of context. In our case tooltips are only appearing on hover and not on click, which can be difficult for users with dexterity problems.

The steps to follow during the processes are only visible during focus, and they are not accessible through the keyboard.

3. Audit of SC level AA

Result	Success criterion	Topic
Not applic.	1.2.4 Captions (Live)	Captions provided for live audio
Not applic.	1.2.5 Audio description (pre-recorded)	Audio description for all pre-recorded video
Warning	1.3.4 Orientation	Content is not restricted to a single orientation
Pass	1.3.5 Identify input purpose	Purpose of the input programmatically identified
Fail	1.4.3 Contrast (Minimum)	Contrast ratio of 4.5:1 or 3:1 on large-scale text
Fail	1.4.4 Resize text	Text can be resized up to 200% without assis. tech.
Pass	1.4.5 Images of text	Can be resized up to 200% without assistant tech.
Fail	1.4.10 Reflow	On 320CSSpx per 260CSSpx height no double scroll
Fail	1.4.11 Non-text contrast	Contrast ratio of 3:1 minimum
Pass	1.4.12 Text spacing	Can be changed: Line height 1.5 font size, spacing...
Not applic.	1.4.13 Content on hover focus	Control on info triggered by hover
Not applic.	2.4.5 Multiple ways	To locate a webpage within a set of webpages
Warning	2.4.6 Headings and labels	Describe the topic and purpose
Fail	2.4.7 Focus visible	Mode of operation where focus is visible
Pass	3.1.2 Language of parts	Can be programmatically determined
Pass	3.2.3 Consistent navigation	Occurs in the same relative order
Pass	3.2.4 Consistent identification	Same functionality is identified consistently
Warning	3.3.3 Error suggestion	Error detected -> provide a suggestion to fix it
Pass	3.3.4 Error prevention	Submission is reversible, data checked + confirmed
Warning	4.1.3 Status messages	Programmed through roles and presented without focus

Pass Warning Fail To be checked Not applic.

Table B.2. Status of compliance of UniCredit Omnichannel with WCAG level AA

1.3.4 Orientation

Warning

So far, using the mobile phone simulation for viewing the prototypes the design is responsive for adapting to both formats, portrait and landscape without losing information or needing to scroll in two directions. But some elements are overlapping and are not readable.

It needs to be refined.

In some cases, you get trapped. Losing access to the logo, your profile or the remaining time of the session.

Developer's comment: Prototypes need to be refined.

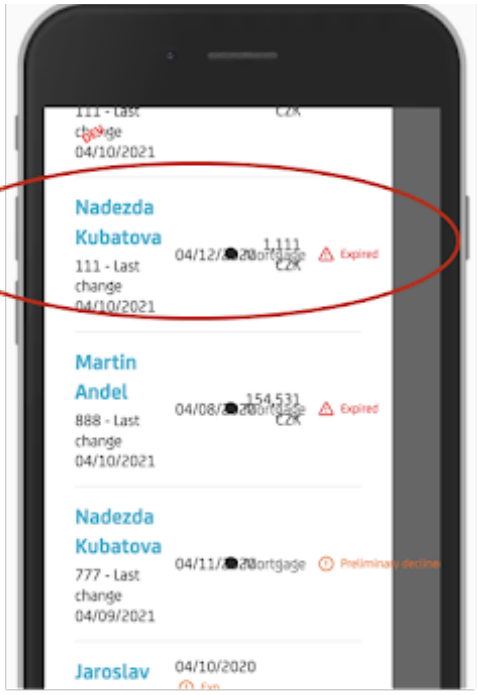

Figure B.10. Vertical visualization generates text interferences.

1.4.3 Contrast (Minimum)

Fail

The contrast ratio for text and images of text depends on the scale of the text:

- Text over 18pt minimum 3:1 contrast
- Text below 18 pt minimum 4.5:1

Inactive components, logotypes and decorative text are excluded.

The main problem is that the primary blue does not comply with the guideline. More information about the color contrast ratio is provided in the analysis of the components.

Figure B.11. Resizing provokes interferences within the text.

1.4.4 Resize text

Fail

Browsers have the option to resize the text of a web page automatically if allowed without needing any additional assistive technology.

In this care when resizing from the browser there is no change at all. But when zooming in till 200% some texts are overlapping.

Some recommendations for avoiding overlapping or disturbing results are:

- Using CSS for layout rather than tables
- Define container dimensions and font sizes in relative units
- Calculate the size and position of the elements that might scale with the text (such as links)

Developer's comment: Prototypes need to be refined.

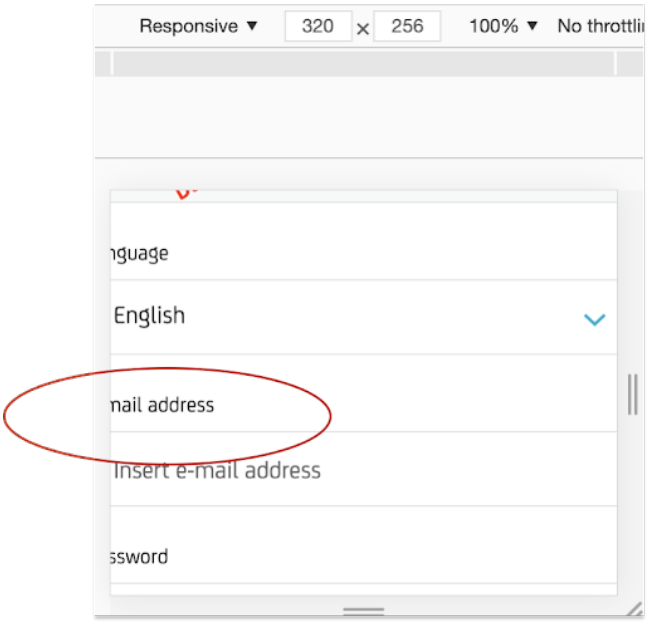

Figure B.12. Display on 320px x 250px generates text interferences.

1.4.10 Re-flow

Fail

If we reduce the screen to a 320 CSS pixels width we cannot see part of the information even if we do some horizontal scrolling.

If the height of the screen is set to 256 CSS pixels we cannot see all the information.

Developer's comment: A grid for defining the layout on 320px x 250px is needed.

1.4.11 Non-text contrast

Fail

The ratio for not text content is at least 3:1 against the adjacent colours, including all the information required to identify user interface components and states, and essential graphics.

More information about the colours allowed can be seen in the analysis of the components.

The contrast of the border of some input fields is not enough 1.3:1, light grey #E5E5E5 with white #FFFFFF.

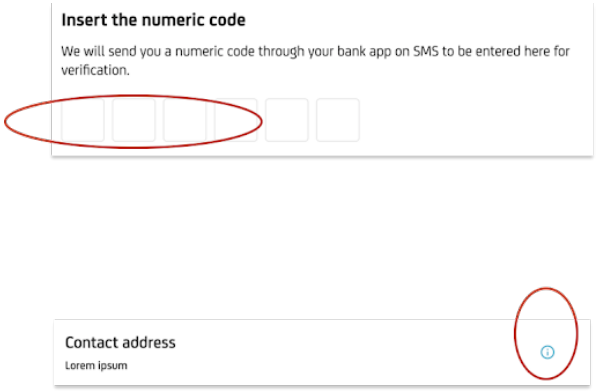

Figure B.13. Pin fields and icons do not comply with the contrast ratio.

- To be compliant keep the grey and lightness of white <39
- To be compliant keep the white and lightness of grey <47

Tool-tips icons do not have enough contrast, so they cannot be identified.

2.4.6 Headings and labels

Warning

Some labels might be too long which makes it difficult to comprehend for people with cognitive disabilities.

Some web pages do not have a title, such as the login page or a general title of the page, e.g. “applications” that can help to locate people using screen readers. It is also related to the absence of a programmed structure using a heading system.

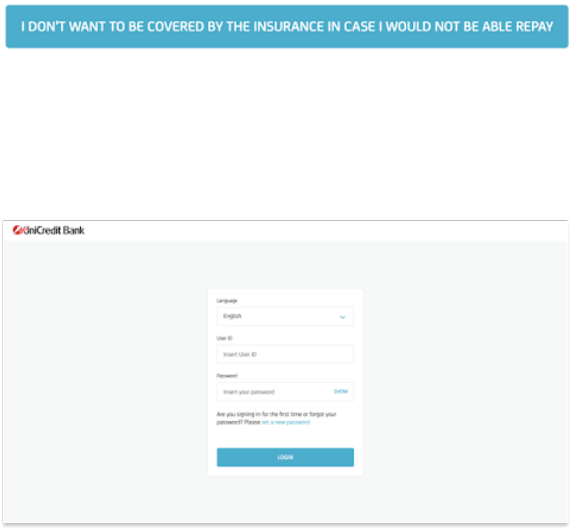

Figure B.14. Buttons with labels too long and absence of titles.

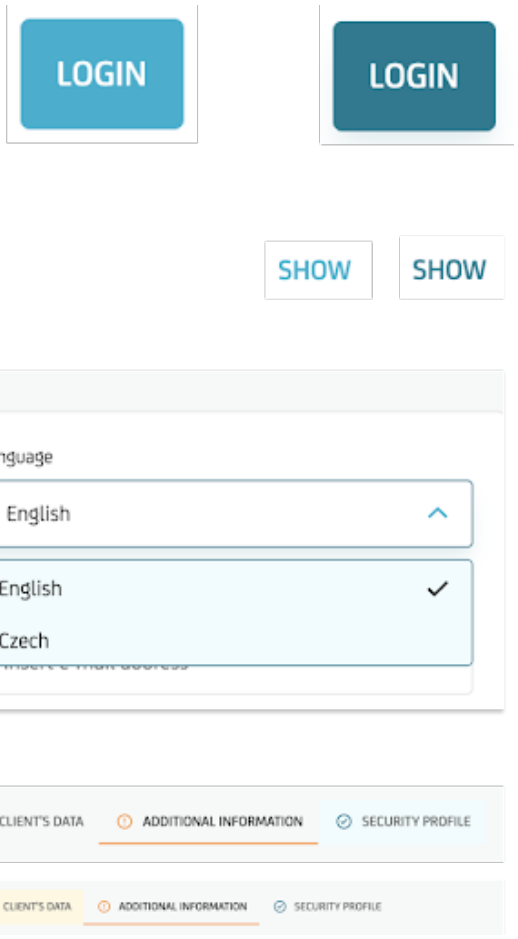

Figure B.15. Examples where focus is not visible or distinguishable.

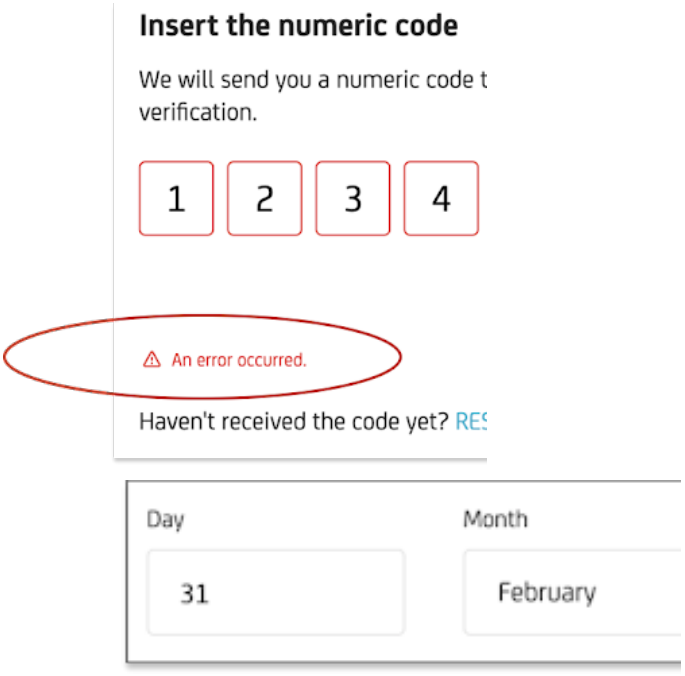

Figure B.16. Examples where errors are not detected or identified.

2.4.7 Focus is visible

Fail

Focus indicator is not clear enough.

The contrast between the primary blue #00AFDO and the accent colour blue #007A91 is too low, 1.9:1 In many cases one cannot really realize that a secondary button is focused.

The hover on the dropdown is also very subtle. Contrast between the light blue #F0FFFCFE and the white #FFFFFF is 1:1. In consequence ,the option you are selecting cannot be visible.

A recommendation to improve it is to use an external border to indicate focus.

The same problem arises with the tabs. Since the contrast between the focus colour and the background colour is not enough the user might not know the current tab selected. As an alternative, the tabs could be indicated with a line, following the example already implemented in Unicredit.

3.3.4 Error suggestion

Warning

The feedback given when an error is encountered should be self-explanatory, identifying and describing the error. Rather than saying a general “an error has occurred” it should say something descriptive such as “the pin code introduced is not correct”.

Invalid format or incorrect data should be detected and prevented by programming. For instance ,the user should not be allowed to set as date of birth February the 31st.

4. To keep in mind from level AAA

This lists the Success Criteria level AAA that could be relevant to keep in mind due to their relation to the topic. Below the list, we can find a small summary of the Criteria.

PERCEIVABLE

- **1.4.6 Contrast (Enhanced).**
  - Minimum contrast ratio 7:1 except for Large text, more than 18px, the nit is enough 4.5:1
  - Parts of inactive users components, decoration or part of other images that contain other useful content.
  - Logotypes

- **1.4.8 Visual presentation.**
  - Background colour can be selected by the user
  - Width is not more than 80 characters or glyphs to help readability
  - Text is not justified
  - Line spacing is at least space-an-a-half within paragraphs and paragraphs space is at least 1.5 larger than spacing
  - Text can be resized without assistive technologies up to 200%without scrolling horizontally to read a line on full-screen window

- **1.4.9 Visual Image of text.** Only allowed for pure decoration or if the text is essential (such as in the case of logotypes)

OPERABLE

- **2.1.3 Keyboard (no exception).** All functionality of the content is operable through a keyboard interface without requiring specific timings for individual keystrokes
- **2.2.4 No interruptions.** Interruptions can always be postponed by the user unless it is an emergency in order to help users with attention deficits, or cognitive difficulties.
- **2.2.5 Re-authenticating.** If the session expires the user can log in

again and continue with the process without any loss of data.

- **2.2.6 Timeouts.** Users are warned of the duration of any user inactivity that could cause data loss unless the data is preserved for more than 20 hours when the user does not take any actions. For this case consultation about privacy and data management should be taken into account and discussed according to the legislation.
- **2.4.8 Locations.** Information about the user's location within a set of Web pages is available. It can be done by including links to the main pages or breadcrumbs to help users with short attention span to feel oriented in a set. of web pages.
- **2.4.9 Link purpose (Link only).** The purpose of the link is described in the. text of the link itself. This means avoiding generic nominations such as "click here" to ensure that individuals, especially those who are users of screen readers, can decide efficiently if that link contains the information they are looking for or not.
- **2.4.10 Section headings.** Section headings are used to organize the content. In this way ,the information is presented in a more structured way helping users with cognitive difficulties, screen readers, or other needs to find the information and understand it in an easier way.
- **2.5.5 Target size.** The size of the target for pointer inputs is at least 44 by 44 CSS pixels except when:
    - ¤ Equivalent: The target is available through an equivalent link or control on the same page that is at least 44 by 44 CSS pixels;
    - ¤ Inline: The target is in a sentence or block of text;
    - ¤ User Agent Control: The size of the target is determined by the user agent and is not modified by the author;
    - ¤ Essential: A particular presentation of the target is essential to the information being conveyed.
- This benefits not only people with dexterity but also the majority. of the mobile devices' users, since it makes the interaction with small screens easier.

UNDERSTANDABLE

- **2.1.3 Unusual words.** A mechanism is available for identifying specific definitions of words or phrases used in an unusual or restricted way, including idioms and jargon. In order to help people who have difficulties decoding words or understanding complex structures. In addition, this criterion makes the web page more inclusive for people with different educational levels.
- **3.1.4 Abbreviations.** Provide a mechanism for explaining the extended meaning of abbreviations.

5. Appreciations using a screen reader

Warning and error messages

If the credentials are wrong once you click on submit or next button an alert appears explaining the situation, but this alert is not automatically read by the system so screen readers users don't know that there is an error.

Developer's comment: Easily solvable.

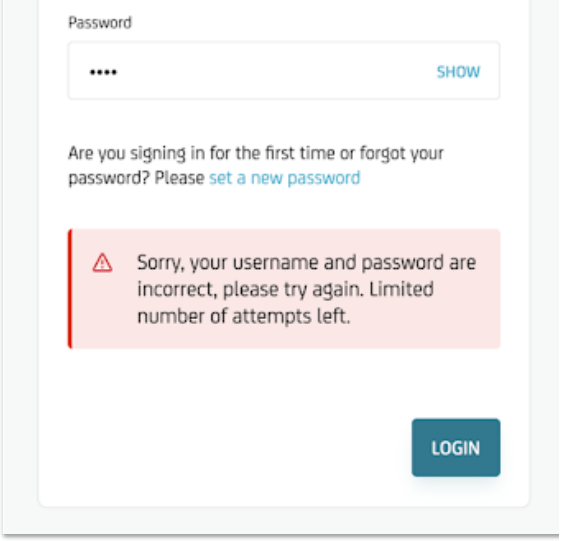

Figure B.17. Feedback message not read by the screen reader.

Loading and status not informed

Loading processed are not automatical informed and neither are changes in conte This means that a user of the screen read does not know when the process is completed.

Developer's comment: Easily solvable.

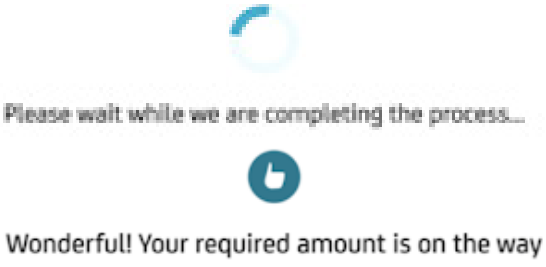

Figure B18. Status messages are not read by the screen reader automatically.

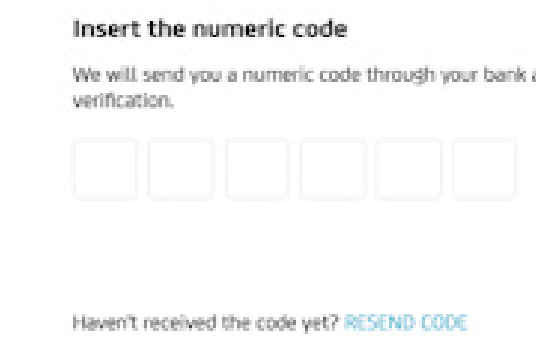

Figure B.19. Input fields for Pin without label or position indicator.

Label and indicator missing

Input field for PIN NUMBER does not have any label or indicator of the position focused.

Developer's comment: Easily solvable.

Figure B.20. Example of icons indicating status.

Lack of context and icons impact

- The percentage of profile data complete is read without any context, just a number so it is difficult to understand for the user.
- The icons are not read, so the user does not have information about the status

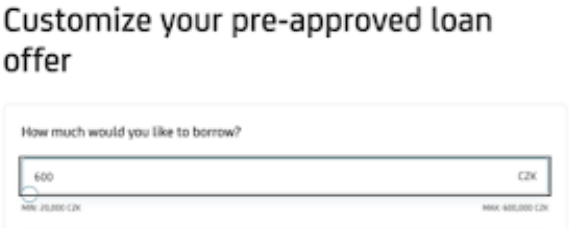

Figure B.21. Example of a stepper with manual input.

Steppers and sliders

The numerical field is identified and programmed as a stepper. It means that the user does not identify that the exact amount can be manually included.

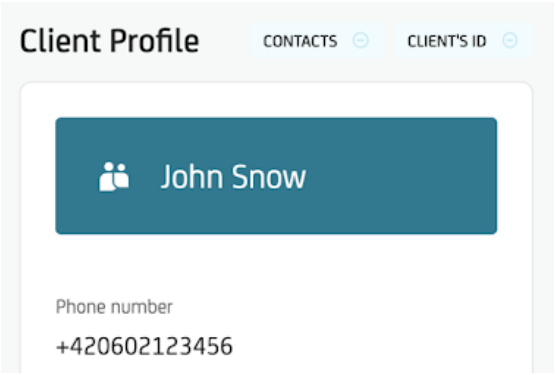

Figure B.22 Mobile number read as a whole

Phone numbers

Phone numbers are read as a whole rather than digit by digit, which makes them difficult to be understood and checked by the user.

E.g: Plus Four hundred six billion six hundred two million one hundred twenty-three thousand four hundred fifty-six.

Developer's comment: Easily solvable.

Pop-ups windows

The system does not recognize the pop-up windows and keeps on focusing and reading the elements in the underlayer rather than the new elements appearing in the pop-up.

Developer's comment: Easily solvable.

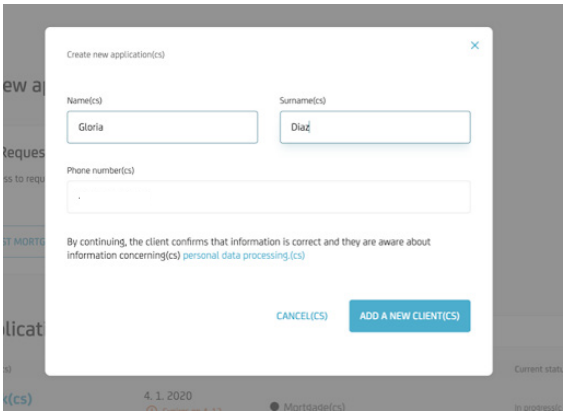

Figure B.23. Example of pop-up window.

Annex C:

Mapping of WCAG 2.0 SC to Functional Performance Criteria

The following table (Table C.1) can be found on the web page of Section 508 created by the GSA Government. It maps the success criteria of WCAG 2.0 with the Functional Performance Criteria (the equivalent proposed by Section 508 to Functional categories on WCAG) in order to highlight the relation, importance and influence of the SC on people with disabilities. The non-conformance of a SC entails the exclusion and inaccessibility of users suffering from the disabilities affected (GSA Government, 2020). This reinforces the idea that all SC level A and AA should be respected in order to comply with WCAG.

The information on the table is only presented as "informational" without presenting any legal bond or being an official statement of the U.S Access Board.

WCAG 2.0 SC	Without vision	Limited vision	No colour perception	Without hearing	Limited hearing	Without speech	Limited Manipula.	Limited Reach and Strength	Limited Language Cognitive Learning
1.1.1 Non-text content	X	X	-	X	X	-	-	-	X
1.2.1 Audio only and video only (prerecorded)	X	X	-	X	X	-	-	-	X
1.2.2 Captions (prerecorded)	-	-	-	X	X	-	-	-	X
1.2.3 Audio description or media alt. (prerecorded)	X	X	-	-	-	-	-	-	X
1.2.4 Captions (live)	-	-	-	X	X	-	-	-	X
1.2.5 Audio description (prerecorded)	X	X	-	-	-	-	-	-	X
1.3.1 Info and relationships	X	X	-	-	-	-	-	-	X
1.3.2 Meaningful sequence	X	X	-	-	-	-	-	-	X
1.3.3 Sensory characteristics	X	X	-	X	X	-	-	-	X
1.4.1 Use of colour	X	X	X	-	-	-	-	-	X
1.4.2 Audio control	X	-	-	-	X	-	-	-	X
1.4.3 Contrast (Minimum)	-	X	X	-	X	-	-	-	-
1.4.4 Resize text	-	X	-	-	-	-	-	-	-
1.4.5 Images of text	-	X	-	-	-	-	-	-	X
2.1.1 Keyboard	X	X	-	-	-	-	X	-	X
2.1.2 No Keyboard trap	X	X	-	-	-	-	X	-	-
2.2.1 Timing adjustable	X	X	-	-	-	-	X	-	X
2.2.2 Pause, stop, hide	-	-	-	-	-	-	-	-	X
2.3.1 Three flashes or below threshold	-	-	-	-	-	-	-	-	-

2.4.1Bypass blocks	X	X	-	-	-	-	X	-	X
2.4.2 Page titled	X	X	-	-	-	-	X	-	X
2.4.3 Focus order	X	X	-	-	-	-	X	-	X
2.4.4 Link purpose (in context)	X	X	-	-	-	-	X	-	X
2.4.5 Multiple ways	X	X	-	-	-	-	X	-	X
2.4.6 Headings and labels	X	X	-	-	-	-	X	-	X
2.4.7 Focus visible	-	X	-	-	-	-	X	-	X
3.1.1 Language of page	X	X	-	X	X	-	-	-	X
3.1.2 Languages of parts	X	X	-	X	X	-	-	-	X
3.2.1 On focus	X	X	-	-	-	-	X	-	X
3.2.2 On input	X	X	-	-	-	-	-	-	X
3.2.3 Consistent navigation	X	X	-	-	-	-	-	-	X
3.2.4 Consistent identification	X	X	-	-	-	-	X	-	X
3.3.1 Error identification	X	X	X	-	-	-	-	-	X
3.3.2 Labels or instructions	-	X	-	-	-	-	-	-	X
3.3.3 Error suggestion	X	X	-	-	-	-	X	-	X
3.3.4 Error prevention (legal, financial, data)	X	X	X	X	X	-	X	-	X
4.1.1 Parsing	X	-	-	-	-	-	X	-	X
4.1.2 Name, role, value	X	X	-	-	-	-	X	-	X
WCAG 2.0 SC	**Without vision**	**Limited vision**	**No colour perception**	**Without hearing**	**Limited hearing**	**Without speech**	**Limited Manipula.**	**Limited Reach and Strength**	**Limited Language Cognitive Learning**

Table C.1. Mapping of SC of WCAG 2.0 and Functional Performace

Table C.2 applies the same principle presented in Table C.1 in relation to the new SC proposed for Mobile accessibility. The adaptation to the Functional Performance Criteria has been evaluated and supervised by the same experts consulted for the validation of the proposed SC.

WCAG 2.0 SC	Without vision	Limited vision	No colour perception	Without hearing	Limited hearing	Without speech	Limited Manipula.	Limited Reach and Strength	Limited Language Cognitive Learning
1.4.A Enable Dark mode	-	X	-	-	-	-	-	-	X
1.4.B Minimum font size	-	X	-	-	-	-	-	-	X
1.4.C High-resolution image	-	X	-	-	-	-	-	-	-
2.4.1 Exp. Enable Speech input	X	X	-	-	-	-	X	X	X
3.3.7 Exp. Alternative to Biometric authentication	X	X	-	X	X	X	X	X	X

Table C.2. Mapping of the Functional Performace and the new proposed SC for Mobile accessibility.

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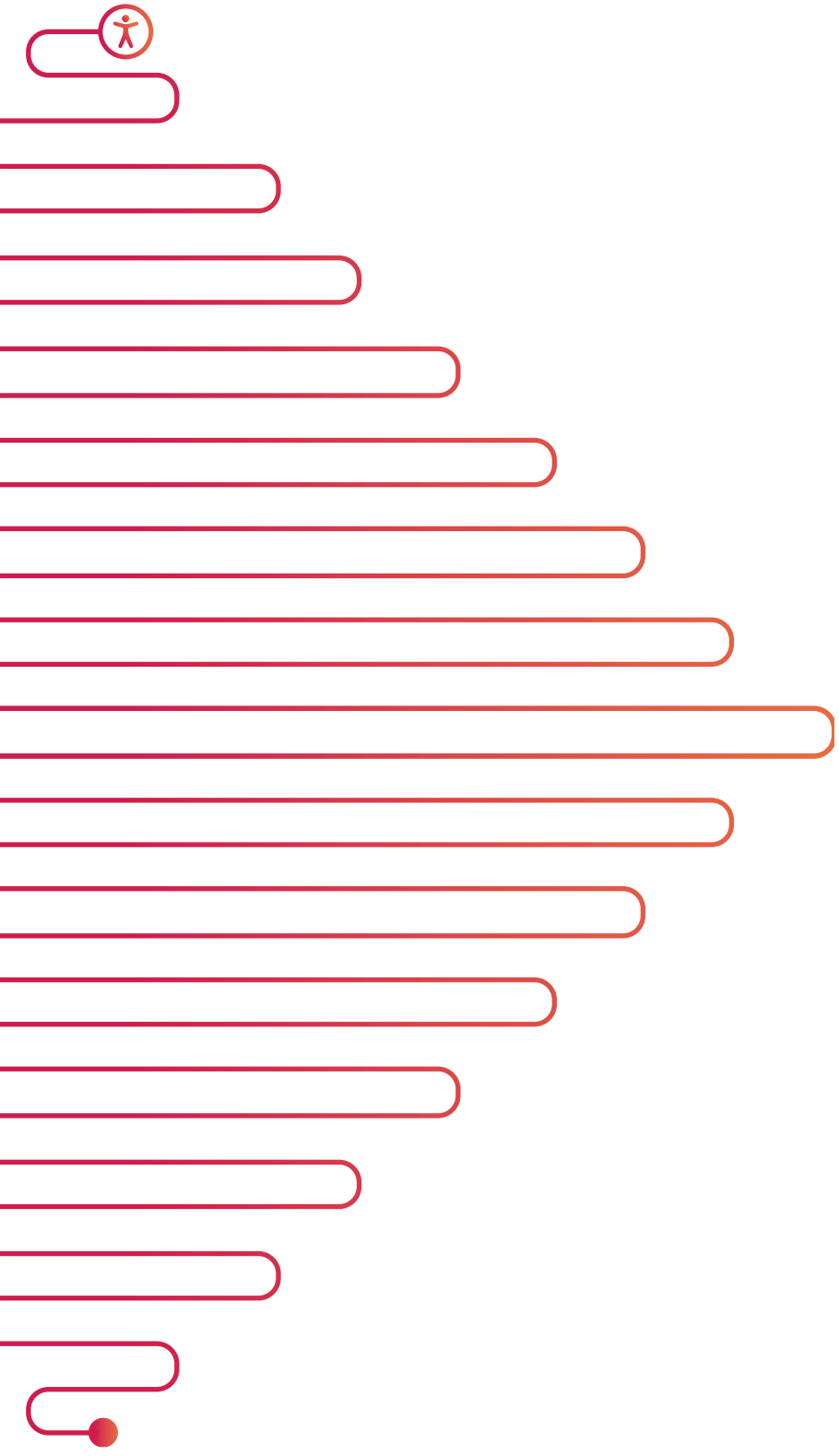

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