Web Accessibility of Irish Government Mobile Applications.

Deirdre Dillon

A dissertation submitted to the University of Dublin

in partial fulfilment of the requirements for the degree of

MSc in Management of Information Systems

2017

Abstract

Web Accessibility is important to all citizens but in particular to citizens with disabilities as well as older people, it is the duty of Government to ensure that online services are available to use for all regardless of age, size and ability. Alongside Web Accessibility, Mobile accessibility which refers to making websites and applications more accessible to people with disabilities when they are using mobile phones and other devices, is becoming increasingly important. All citizens benefit from applications which are developed with accessibility in mind not just people with recognised disabilities. Government and public bodies must develop applications which encourage full use by all citizens. The increased use of mobile devices by citizens presents both a challenge and an opportunity to Government bodies. The challenge is ensuring applications work across differing device platforms. The opportunity is increased online access and use balanced against cost savings of manual efforts.

This research aims to evaluate the web accessibility of Government mobile applications and, where appropriate suggest solutions to enhance their accessibility and for further development. Solutions to make the mobile applications compliant will be in line with the National Disability Authority guidelines and web accessibility guidelines but will be tailored for mobile applications. At present no guidelines exist for mobile applications.

The research explored alternative accessibility evaluation tools to test five Government departments and Government public bodies mobile applications on android and IOS platforms. The mobile applications tested were:

1. Revenue Commissioners, RevApp
2. Department of Agriculture, Food and the Marine, Mobile site
3. Department of Foreign Affairs, TravelWise App
4. Failte Ireland, DublinTrails App
5. Transport Ireland, RealTime App

The testing was comprehensive and went beyond the home pages of these applications and included manual testing which is necessary for complete accessibility evaluation.

Although Government bodies have signed up to the National Disability Authorities protocol on inclusive design all the mobile applications tested were found to be not accessible. There is a need for established guidelines and a testing framework to ensure eGovernment mobile applications are accessible to all.

Acknowledgements

Thank you to my family and friends for their support over the last two years.

I would like to thank my supervisor, Howard Shortt for his guidance and advice.

Also, thank you to my colleagues in the Department of Agriculture, Food and the Marine for their encouragement.

Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university. I further declare that this research has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics.

Signed: _____

Deirdre Dillon

Date: 29th September 2017

Permission to lend and/or copy

I agree that the School of Computer Science and Statistics, Trinity College may lend or copy this dissertation upon request.

Signed: _____

Deirdre Dillon

Date: 29th September 2017

Contents

List of Tables and Diagrams

Abbreviations

WCAG	Web Content Accessibility Guidelines
Apps	Applications
HTML	Hyper Text Markup Language
XML	eXtensible Markup Language
CSS	Cascading Style Sheets
EU	European Union
CSO	Central Statistics Office
NDA	National Disability Authority
W3C	World Wide Web Consortium
iOS	Iphone Operating System
OS	Operating System
CAP	Common Agriculture Policy
CFP	Common Fisheries Policy
SFP	Single Farm Payment

1. Introduction

1.1 Context and Rationale for The Study

Web accessibility which includes the accessibility of mobile applications is about to become a legal requirement across the EU as it works towards a single digital market. The EU recognises the importance of digital inclusion for all citizens and is making this a legal right. The web accessibility directive which came into force on 22 December 2016 works to ensure that people living with disabilities will have improved access to mobile applications and websites of public service bodies. From 23rd September 2018, all member states need to include the right to accessibility on the websites and mobile applications of public sector bodies written into their national legislation, this legislation will then become the law (Citizens Information 2016).

Given this upcoming legal requirement this research examines the current accessibility of eGovernment mobile applications to determine if they are accessible as deemed by the Web Content Accessibility Guidelines (WCAG) 2.0 guidelines.

eGovernment is defined as "simply the use of information and communications technology, such as the Internet, to improve the processes of government." (Gordon, 2002).

Previous studies by Mulvey in 2008 (Mulvey 2008) and Cunningham, Dempsey, Marcaigh, Philips and Quirk in 2012 (Cunningham et al 2012) into the web accessibility of eGovernment websites over the last 10 years has found a lack of accessibility and no apparent standard being applied across Government bodies, making it confusing and difficult for Irish Citizens living with disabilities to access public services.

1.2 Background

There is a growing popularity and use of mobile devices among Irish people, a third of all web usage comes from smartphones (Weckler 2015), along with the evidence that Irish people are the biggest phone internet users in Western world, together with the constant technological improvements in the field has led to Irish Public bodies developing mobile applications with the aim to offer fuller inclusion to all citizens. In this context, web accessibility which includes mobile accessibility is a growing issue and cannot be

deprioritised. Its increased importance is reflected in the normal use of eGovernment services and more recently the development of mGovernment services. "The traditional focus of e-government services research has been on non-mobile services but now with the incorporation of mobile services more people are able to access these Mobile e-government services (m-government services)", (Hung S, Chang C, Kuo S 2013).

An EU Directive on making the accessibility of websites and mobile apps of public sector bodies a legal right will be enforced by 22nd September 2018, this directive aims to provide people with disabilities – especially persons with vision or hearing impairments – to have better access to the websites and mobile applications of public services. The overall objective of the directive is to ensure that no member of society is excluded from the use of digital services. Accessibility, whether on websites or mobile applications ensures that all citizens regardless of ability can access public services. The directive will ensure that Government agencies have both a moral and legal obligation to develop with accessibility as a key requirement.

This research dissertation will look at several mGovernment applications to analyse the current state of accessibility. The mobile applications are be evaluated on both android and iOS platforms as these platforms dominate the tablet and mobile phone market share. The applications to be included in the research are:

- Department of Agriculture, Food and the Marine – Mobile website
- Department of Foreign Affairs – TravelWise App
- Office of the Revenue Commissioners - RevApp
- Failte Ireland – DublinTrails App
- Department of Transport – RealTime App

These mobile applications will be tested using standard accessibility tools as advised by the Web Content Accessibility Guidelines (WCAG) on their website (W3, 2017). The mobile applications will be tested to ensure they are compatible with device specific screen readers and to check if they are compliant with HTML, XML and CSS standards. They will also be audited against the WCAG 2.0 guidelines.

The objective of this dissertation is to create a testing framework for developers of Government mobile applications to follow for applications to be compliant with the impending legal requirements on accessibility. This framework will identify common issues of inaccessibility across the mobile applications and provide suggestions and solutions to these issues. The research will also look towards contributing to the WCAG mobile accessibility task force which is undertaking the task to develop more specific and updated guidance on

mobile accessibility. At present, mobile accessibility is included under the general WCAG 2.0 guidelines. The research will also advise Government departments responsible for the development of the mobile applications, on their current state of maturity and compliance regarding accessibility, as the 2018 deadline draws closer.

This research differs from other research in this area as it will focus in depth on the accessibility of five Public Bodies mobile applications on both iOS and android platforms, in contrast to the WCAG guideline of surface based, home page analysis of the corresponding applications. Specifically, this research examines the core functionality from the perspective of able bodied individuals and compares the fullness of use for individuals with disabilities.

1.3 Research Question

The primary research objective as outlined is to determine a rating of compliance in accessibility standards for government and public body mobile applications in Ireland. The focus of this study will seek answers to the following sub-questions.

Q1 Do Irish Government Mobile applications comply with the WCAG 2.0 guidelines?

Q2 Are these mobile applications compliant with the EU Web Accessibility Directive?

Q3 How can the WCAG 2.0 guidelines be improved regarding mobile accessibility?

1.4 Why and To Whom Is This Study Important

In Ireland, there are many people living with various disabilities. In the 2011 census, the central statistics office (CSO) reported that 595,355 people, 13% of the population have a disability of some kind (CSO, 2011).

Naturally as we age, the number of people who are classified as having a disability increase. In the 2011 census there was a reported 24,764 people in the 25-29 age range living with a disability compared to 42,686 in the 65-69 age range.

As people age the likelihood of them having a disability increases, so as our population rapidly ages, “Currently there are 540,000 people aged 65+ in Ireland which accounts, for 12% of the total population. This is set to rise to 1.4m, or 22% of the total population, by 2041” (CSO 2013), more people will live with disabilities making web and mobile accessibility of public sector bodies vitally important.

According to the National Disability Authority (NDA 2017) five different categories of disabilities exist which affect a person's interaction with the web:

Visual disability such as blindness, low vision or colour-blindness.

Hearing disability such as deafness or hard-of-hearing.

Motor disability such as inability to use a mouse, slow response time or limited fine motor control.

Cognitive disabilities which includes learning difficulties and inability to remember or focus on large amounts of information.

Seizures, photo epileptic seizures brought about by flashing effects or strobe lighting.

The international standard ISO/TS 20282-2:2013 (ISO 2013) defines accessibility as: "usability of a product, service, environment or facility by people with the widest range of capabilities."

Websites and mobile applications deemed accessible enable individuals with the above disabilities to interact with the internet. It would be unwise of public bodies to develop applications which may exclude up to 13% of the population; many people with a disability want to use the latest mobile and online technology and there is also a growing number of older people also accessing the web, CSO figures show an increase of 7% between 2015 and 2016 of older people aged between 60-74 accessing the web (CSO 2016). The National Council for the Blind Ireland, which offer services to the 224,000 people in Ireland who are blind or vision impaired, hosts regular technology podcasts on its websites which actively encourages and advices users on how to access and use technology.

There is a general understanding that accessible friendly websites and mobile applications benefit all in society including older people with changing abilities due to aging which is important not only the examined Irish context, but also for other aging society countries such as China.

In 2014 the Department of Public Expenditure and Reform released its One Vision, Civil Service Renewal Plan (DPER 2014), within this plan there is an ICT Strategy for delivering better outcomes and increasing efficiency through innovation and excellence. The Department of Public Expenditure and Reform state that "All Irish public bodies are obliged to treat public funds with care, and to ensure that the best possible value-for-money is obtained whenever public money is being spent or invested." Therefore, there is a responsibility on IT sections along with business areas within departments to ensure that

online services are accessible to all. It should be of interest to the five Government Departments and public bodies included in this study to learn the rating of their applications towards accessibility standards in preparation of the upcoming 2018 deadline.

1.5 Scope

The scope of this dissertation is to discover if the mobile applications recently developed by various Government Departments and Public Bodies comply with the Web Content Accessibility Guidelines 2.0 and the AA level of conformance as Government departments and public bodies have signed up to achieve. There are three levels of conformance, A, AA and AAA. By achieving AA level of conformance, no group should have issues accessing the applications. The research will also include a testing framework to help software development teams of these applications to develop with accessibility as a key requirement. This will be of benefit to all mobile application users and to development teams as it will provide them with a framework to help comply with the upcoming changes in the legislation. At the moment guidelines only exist for websites which can be challenging to apply to mobile applications. The framework will also explain the common problems which cause inaccessibility and provide solutions for them. The research will also discuss if mobile applications development is the best use of public funds and recommend alternatives where viable.

1.6 Timeframe

Work on this research began in at the start of the academic year with most of the literature review and selection of research methods completed by end of June 2017.

Testing of the websites on both android and iOS platforms was completed in July 2017.

Analysis and Findings work was completed in September 2017 and conclusions along with recommendation completed in September 2017.

1.7 Roadmap of Chapters

The dissertation is structured in the following way to ensure the reader has a clear concise overview of the methods involved in this research.

Chapter 2 reviews existing research around mobile application accessibility and associated topics. This research involves an analysis of existing literature and information on mobile accessibility including a definition and examination of the guidelines and legislation, both current and upcoming, surrounding web and mobile accessibility. This chapter will also cover research into the area of mobile development on iOS and Android platforms and the difficulties faced by development teams with the multiple devices available on the market.

Chapter 3 is the Methodology and Fieldwork chapter, this chapter will provide a review of the research methodology selected to carry out this study and provides a rational for its selection. A framework to conduct the testing will be explained and it will describe the functionality of the five tested mobile applications and the accessibility tools used to conduct the testing. These methods were used in an approach to answer the research question "How can the accessibility of Government Mobile Applications be improved".

Chapter 4 is the Findings and Analysis chapter which discusses the results from the testing of the five mobile applications. It gives particulars of the testing conducted on the mobile applications and outlines the main problems encountered on a department by department basis. Also, details are given into the methods of testing applied to each mobile application and the techniques used to analyse the findings.

Chapter 5 is Conclusions and Future Work chapter which discusses the main findings of this research. Its gives details of how the research conducted and its findings can be used in conjunction with WCAG 2.0 guidelines for future mobile application development by Government and public bodies. This chapter will also link future work in the context of the public bodies' obligations.

2. Literature Review

2.1 Introduction

The purpose of this literature review is to analyse the available literature pertinent to web accessibility but focusing on mobile accessibility.

It begins with a review of current and future guidelines, standards and legislation regarding both web and mobile accessibility, turning to the tools that enable web accessibility among the disabled.

Many studies have been undertaken to evaluate the accessibility of e-Government websites using various techniques and methods.

The chapter also considers the different types of mobile application development and the known issues with accessibility associated with each type.

The chapter then concentrates on the web accessibility of government sites here in Ireland, the EU and across the globe. While there is a wide range of literature regarding web accessibility, there is little that focuses on mobile accessibility as a different entity.

The available data on web accessibility is quite current with major studies done on Irish Government websites in 2006, 2008 and then again in 2014 which gives a good historical view of the issue. This chapter will discuss the available literature based on these topics.

2.2 Guidelines, Standards and Legislation

2.2.1 Legislation and Standards

At present in Ireland, the main legislative act which covers web accessibility is The Disability Act (Government of Ireland, 2005). Other acts such as the Equal Status Acts (Government of Ireland, 2015) prohibit discrimination in the provision of goods and services on grounds of disability. The National Disability Authority has produced a code of practice on Accessibility of public services and information, which is provided to public bodies (National Disability Authority, 2015). This code of practice outlines an understanding of what is required under The Disability Act and is designed to guide public bodies in meeting their statutory obligations by providing practical advice and examples.

All public bodies are obligated to ensure that their websites and mobile applications are accessible. The growing importance of this obligation is reflected in the proposed European Accessibility Act (Europa 2017) which falls under the European Disability Strategy 2010-2020 (Europa 2010), this legislation will supersede national law, as the EU thought it was necessary due to both different standards across countries in the EU and a lack of legislation covering the need for accessibility in others. The act does not only focus on public bodies but includes; Air, bus, rail and waterborne passenger transport services, banking services, E-books, E-commerce plus many more consumer services. The act aims to provide better access for people with a disability to online services and observes that better accessibility will also have a positive impact on older people in society.
Many countries have different standards regarding accessibility;

Sweden, The Swedish Government has developed a set of guidelines for public sector web sites. These guidelines which are a child of the WCAG guidelines are fully incorporated into the full software development life cycle, ensuring that accessibility is not an afterthought in the process. It is generally accepted that Swedish public-sector web sites achieve a high level of accessibility, Stephandis (Stephandis 2011) states that the Swedish success can be attributed to a good understanding of the guidelines among the websites administers and via regular evaluations and compliance measurements. It's inferred that this higher level of awareness coupled with continuous evaluation and measurement has led to the high level of digital accessibility throughout Sweden's content publishers.

Germany, The German Government introduced the Creation of Barrier-Free Information Technology in accordance with the Act on Equal Opportunities for Disabled Persons in 2002. The Barrierefreie-Informationstechnik-Verordnung (BITV) requirements only apply to German federal government web sites but all public body websites are encouraged to comply. The BITV conformance requirements are in line with WCAG 2.0 guidelines.

UK, The British Standards Institute released the standard BS 8878:2010 Web accessibility, in 2010 which is backed by the UK Equality Act 2010. This standard aims to incorporate accessibility throughout the product lifecycle and recommends involving people with disabilities in the process. The standard which can be used by any organisation also draws on the WCAG 2.0 as guidance.

Canada, in 2011 the Canadian Government released the Accessibility for Ontarians with Disabilities Integrated Accessibility Standards. These standards which fall under the Accessibility for Ontarians with Disabilities Act look to provide guidance to both public and

commercial entities which must by law achieve WCAG AA compliance by 2021. The standards apply to all newly published websites and will expect compliance by existing websites by 2021. These standards define a web site as “a collection of related web pages, images, videos or other digital assets that are addressed relative to a common Uniform Resource Identifier (URI) and are accessible to the public” (Ontoria 2016) thus also apply to mobile applications.

2.2.2 W3C Guidelines

W3C (World Wide Web Consortium) works towards creating standards of web technologies, according to Herman (Herman, 2006) standards are important to make the web accessible to all. The Web Content Accessibility Content 2.0 guidelines produced by W3C aim to provide “essential details for accessibility of Web pages avoiding barriers during the use of Web contents” (Willie, Willie, Drumke 2016). Willie, Willie and Drumke also note that many countries around the world have adopted these guidelines with modifications.

The WCAG 2.0 guidelines are broken down into four areas; Perceivable, Operable, Understandable and Robust, as shown below in figure 1. There are three level of conformance, A (lowest), AA, and AAA (highest). In total there are 63 success criteria and a breakdown of each success criteria and conformance level they achieve is included in appendix 1. Level A conformance is deemed the minuimum level of accessibility.

Principles	Guidelines	Level A	Level AA	Level AAA
1. Perceivable	1.1 Text Alternatives	1.1.1		
	1.2 Time-based Media	1.2.1 – 1.2.3	1.2.4 – 1.2.5	1.2.6 – 1.2.9
	1.3 Adaptable	1.3.1 – 1.3.3		
	1.4 Distinguishable	1.4.1 – 1.4.2	1.4.3 – 1.4.5	1.4.6 – 1.4.9
2. Operable	2.1 Keyboard Accessible	2.1.1 – 2.1.2		2.1.3
	2.2 Enough Time	2.2.1 – 2.2.2		2.2.3 – 2.2.5
	2.3 Seizures	2.3.1		2.3.2
	2.4 Navigable	2.4.1 – 2.4.4	2.4.5 – 2.4.7	2.4.8 – 2.4.10
3. Understandable	3.1 Readable	3.1.1	3.1.2	3.1.3 – 3.1.6
	3.2 Predictable	3.2.1 – 3.2.2	3.2.3 – 3.2.4	3.2.5
	3.3 Input Assistance	3.3.1 – 3.3.2	3.3.3 – 3.3.4	3.3.5 – 3.3.6
4. Robust	4.1 Compatible	4.1.1 – 4.1.2		

FIGURE 2.1: Tree structure of WCAG 2.0 success criteria (Willie, Willie and Drumke 2016)

As observed by Willie, Willie and Drumke (Willie, Willie and Drumke 2016) and reinforced by the need for the European Accessibility Act, there are several different guidelines within Europe and throughout the world, providing direction on how to create accessible websites. Most of these guidelines have no exact details on mobile application accessibility but imply that all web services, however they are developed or from whatever device they are accessed, should be accessible.

2.2.3 Android and iOS guidelines

Both Google and Apple have produced accessibility guidelines for developers of android and iOS applications. Unlike the WCAG 2.0 guidelines, which are independent of technology, the android and iOS guidelines are produced exclusively for mobile application accessibility.

Google have developed an android developer guide to accessibility (Andriod 2017) which advises android developers on best practices, basic accessibility principles and testing techniques that constructs a mobile application which is accessible to all.

Apple have developed an Accessibility Programming Guide for iOS (Apple 2017) which gives guidance to iOS developers on making their mobile applications accessible with focus on ensuring that mobile applications are accessible by VoiceOver users.

2.3 Web Accessibility Tools

There are many tools available for people with disabilities to help with them with assessing the web. Bouck (Bouck 2017) states that assistive technology is not only tools and devices but also the services which help support people with disabilities.

Assistive Technology refers to practical tools and services that enhance independence for people with disabilities and older people. It is “any item, piece of equipment or product system whether acquired commercially, modified or customized that is used to increase, maintain or improve functional capabilities of individuals with disabilities” (World Health Organisation 2015).

As the use of mobile devices and mobile applications has exploded in recent years so has the assistive technology available to support the use of these new technologies. Most mobile devices come with built in assistive technology but this varies between brands.

Apple who operate the iOS platform has a built-in screen reader, VoiceOver, a recent survey by WebAim (WebAim 2016) showed that VoiceOver was the most commonly used screen

reader among mobile screen reader users. The android version TalkBack, was the second most commonly operated screen reader among the same user group. VoiceOver acts as a gesture based screen reader, Apple state “We believe that technology should be accessible to everyone” (Apple, 2017) and designed for everyone. In 2017, Tim Cook, the CEO of Apple, stated that accessibility is a basic core value for Apple (Miller, 2017).

Although, not exclusively thought as assistive technology Apple’s Siri and Google’s Now, intelligent personal assistants, work with voice recognition technology and offer people with motor difficulties, who struggle or cannot use a keyboard or mouse, the ability to interact with their device.

Many more assistive technology applications are available, from screen magnifiers, voice recognition, text to speech from the apple store and google play store which when downloaded help with the inclusion of people with disabilities.

In their research on assistive technologies and applications for blind users on mobile platforms, Csapó, et al., (Csapó, et al. 2015) surveyed and evaluated the many tools available for blind users to assist them in their use of mobile technologies. The authors included and assessed both iOS and android tools which focused on the available built-in screen readers VoiceOver and Talkback. The research concluded that the iOS built-in screen reader VoiceOver had several advantages to users over the android built-in screen reader TalkBack with users experiencing less issues when operating VoiceOver on iOS applications.

It is important that mobile applications being developed by Government and Public bodies support the use of assistive technologies be it inbuilt technologies available on the device or downloaded applications as they can greatly enhance the independence of a person with disability.

2.4 Mobile Application Development

“A mobile app is a software application developed specifically for use on small, wireless computing devices, such as smartphones and tablets, rather than desktop or laptop computers.” (Techtarget 2013), these applications are accessed by a touchscreen. The mobile technological world has changed dramatically over the last ten years – iPhone was

introduced in 2007, the app store and containerised applications were introduced in 2008 with the introduction of iOS 2.0

Commercial companies following Apple's lead responded to this change of how consumers interacted with the internet by developing mobile applications which worked and looked better on the new tablets and smartphones. It is not surprising that Government departments and public bodies have followed suite and have developed mobile applications.

The mobile market is dominated by two main competitors Apple and Google which offer iOS and android, which are the operating systems. Current research by Gartner (Gartner 2016) states that worldwide "In terms of the smartphone operating system (OS) market, Android regained share over iOS to achieve an 86 percent share in the second quarter of 2016". Mobile application development involves ensuring that the application works on a given user's preferred device – smartphones and tablets - but also work consistently across different devices with different screen sizes and a mix of operating systems, sometimes interchangeably having profound impact on development, making it more challenging. The complexity is explained by Bergvall-Kåreborn and Howcroft (Bergvall-Kåreborn and Howcroft 2014) "Screen real estate, processing power and data abilities vary across each mobile device. A solution that works and looks good on an Android phone may not port well to another device. The effort to port these apps to new languages and devices could be as much effort as developing a new application." Mobile applications are aiming to achieve the goal of working with 'any device, any platform', like software such as Adobe PDF which had the goals of returning the same interaction and experience no matter what platform or operating system was used to view. This implies that mobile application development is costly and time consuming without having to consider the extra complexity of accessibility.

There are two main types of mobile content, mobile web content and native mobile apps. Mobile web content is created to be used in a web browser on a mobile device. The web content generally uses similar JavaScript frameworks such as Jquery and markup as desktop content.

As explained by Shelley and Vermaat (Shelley and Varmaat 2008), javascript is a programming language of the internet and allows developers to create interactive web pages and Jquery allows the easier use of javascript on the webpage and markup languages such as HTML are used to create webpages.

Native mobile apps are apps created in the native platform using environments such as Google's Android Software Development Kit or Apple's iOS Cocoa Touch framework.

Mobile application development involves several different programming languages which depend on the platform being developed upon, android or iOS. For Android, HTML 5, Java and Javascript are popular programming languages used and Objective-C and Swift are popular for iOS.

HTML 5, Javascript, CSS 3 and Swift allow the development of highly interactive mobile applications but may introduce some accessibility issues such as difficulty navigating with assistive technologies, lack of user control over automated content changes and hidden content.

This research will conduct testing on both mobile web content and native mobile apps.

2.5 Web and Mobile Accessibility

In 2008, a call was put out by Langdon, Clarkson and Robinson (Langdon, Clarkson and Robinson 2008) for development of computer interfaces to move from user-centered design to a more inclusive user design. This was in recognition that more inclusive design not only makes a product more user friendly but also can introduce a product/service to more users by making it more accessible. Web accessibility is removing the barriers which enables people living with a disability to use the web, hence mobile accessibility is removing the barriers which enables people living with a disability the ability to use the web and mobile applications.

2.5.1 Irish eGovernment Websites

Several previous studies have been undertaken to evaluate the level of web accessibility of Government Departments and Public Body websites.

In 2006 a study into the accessibility of eGovernment websites, along with public agencies and political parties was completed by Red Cardinal (Red Cardinal 2006). The study was comprehensive in the range of websites but narrow in the penetration of the websites tested, by only testing the home page of 41 websites which included the website of The Department of Agriculture and the Office of the Revenue Commissioners. This study was completed during a time that Government policy was starting to encourage online services (Revenue online was launched in 2003) and the public were engaging in an increasing number.

The study accessed the websites against the WCAG 1.0 guidelines with accessibility tools such as Total Validator and Wave.

Total Validator is an accessibility tool which will “validate your HTML and CSS, check that pages are accessible, run a spell check, and check for broken links, performing a one-click validation of your website.” (Totalvalidator 2017)

Wave is an accessibility tool which will help developers determine if their website is accessible (WebAim 2017).

The researchers also deemed that some manual testing on the websites was necessary for full inclusion, this is further enforced by WebAim (WebAim 2017) who state, “Only a human can determine true accessibility” and the tools should only be used to assist in the accessibility process. The Red Cardinal study showed that in 2006 there was awareness by some Government bodies that accessibility was necessary by having accessibility statements on their websites. At the time, there was requirement that the websites of Government bodies achieved a single A standard against the WCAG 1.0 guidelines which is the bare minimum, most of the websites tested, 27 out of 41, passed this minimum threshold.

One of the major concerns raised by the study was the declaration by some 2 websites that they had achieved a AAA standard and 4 that had achieved AA standard against the WCAG 1.0 guidelines but the researchers determined that only 1 website achieved the stated AA standard. The research showed out of the 41 tested websites tested, only 1 had gone beyond their stated standard.

The study infers that both the online services and web accessibility were in their infancy and that teams responsible for the provision of the websites were more concerned by having a website available, and accessibility wasn’t a major concern or interest to most.

In 2006, researcher Trulock (Trulock, 2006) examined the progress of web accessibility across the public-sector websites by conducting testing of the sites and comparing the results to previous studies. This study compared results gathered in 2002 to their own data gathered in 2005 and considered the progress made by public bodies in making their websites accessible. Once again, the testing concentrated on the home page of the websites but a large number (151) websites were examined for accessibility against the WCAG 1.0 guidelines.

Trulock states that both automated and manual testing is necessary to uncover the true state of accessibility and using automated tools alone gives a false perception of accessibility.

The study discovered a major lack of accessibility by most websites tested, most failed to achieve even simple compliance of WCAG 1.0. This lack of compliance demonstrated a failure to improve upon the 2002 data, highlighting the inaccessibility of the websites.

Their study also considered ways to improving web accessibility and advised that education and training of web development teams in accessibility may be necessary. As such a comprehensive study was completed, a summary of the most common barriers to accessibility among the public service websites could have been provided to offer help and guidance to development teams.

In 2008, a study into the Accessibility of eGovernment websites (Mulvey 2008) was conducted which also included a survey and interview of personnel whom worked on or were responsible for the development of the websites. The study looked to build on the previous studies done by Red Cardinal on the accessibility of Government websites (Red Cardinal 2006). This study focused on a narrow range of previously accessed websites but included a more comprehensive depth of the websites which went beyond their homepage. It also aimed to build up an understanding of accessibility amongst the development teams and went beyond just technical issues.

One major difference between Mulvey's study and studies conducted in previous years was the introduction on the Disability Act in 2005 giving legal grounds for the need of accessible websites. This would suggest that a significant awareness of accessibility and compliance of standards was achieved. The study was also conducted with the knowledge among participants that the WCAG guidelines were being updated from 1.0 to 2.0.

Mulvey's study despite being limited to five websites, found that web accessibility was still an issue, with all the five websites tested containing accessibility problems. The study also highlighted different accessibility standards across the websites, with one Department not having any accessibility statement on their website. The other Department websites tested differed in their approach by aiming to achieve either AA or AAA standard.

The study did a comparison against the RED Cardinal data gathered against the same websites and found that two websites had deteriorated on their accessibility, two had improved and one remained the same. Even though Mulley's study tested more webpages belonging to each website the comparison was done against the homepages only.

This finding that accessibility was irregular across eGovernment websites is further supported by the interviews conducted during the research. The findings from the interviews suggested that respondents still were not fully aware of how to achieve accessibility on their

websites, with some developers stating that accessibility may have an impact on functionality. Major themes around lack of education and training for accessibility, lack of knowledge for the technology associated with achieving accessibility and lack of awareness for disabilities and the impact on accessing the web were discovered during the research.

It is not clear from the research if the respondents were from the Departments whose websites were tested, it may have been more beneficial if the responses received could have been matched against each tested website. This approach could have further highlighted the need for extra training for staff involved in the development of websites at all levels not just developers and the requirement that accessibility is part of the development life cycle from the start.

In 2012, the NDA commissioned substantial research into the accessibility of eGovernment websites (Cunningham et al. 2012). This research analysed the websites of 11 public bodies and interviewed both end user representatives and personnel responsible for the development and maintenance of the websites. The websites chosen for evaluation were chosen due to their popularity and use, the researchers discovered these websites may have had more resources assigned during the development process.

The research completed differs from the Red Cardinal work in 2006 and Mulvey in 2008 by evaluating the websites based on the universal design guidelines produced by the NDA rather than focusing specifically on the WCAG guidelines. Also, in 2012 the WCAG guidelines had been updated from 1.0 to 2.0 and the universal design guidelines are based on WCAG 2.0.

This is the first study which also mentions mobile applications and introduces them into the study, at the time of the research four of the public agencies also had mobile applications available for download and three had a separate mobile version of their webpage. Unfortunately, no accessibility evaluation of the mobile applications was completed and the research focused on the main websites only.

The research clearly shows a growing awareness of accessibility among public sector staff, the personnel surveyed considered accessibility a priority and this was confirmed by accessibility statements on their websites and by naming conformance with the WCAG standards as a necessity on tenders.

An interesting observation was made by one of the respondents on the future use of mobile applications and accessibility “Mobile design can be much more accessible by default because of the constraints imposed by the platforms put on the design and the amount of

content you can realistically present.", this suggests a belief that accessibility is a by-product of mobile application development but all applications still need to be tested for accessibility. All the respondents stated they envisage the development of mobile applications and a mobile version on their websites in future developments, if they were not already doing so.

This study also included user testing, users included people with various disabilities (blindness, low vision, deafness and dyslexia), older users and included users without disabilities. The total number of testers in the group was eleven, which the researchers involved in the study stated was generally accepted as good number of people to complete user testing. Research conducted into usability testing has found five users to be an optimum amount, based on return on investment, for most testing studies (Neilsen 2012). Testing focused on usability and accessibility and the user testing also included mobile usability but this testing was limited to accessing the main websites on mobile devices rather than mobile applications.

The user testing completed on accessibility disappointingly "found that accessibility is not a priority for public sector websites; less than half of those reviewed featured a written commitment to a level of accessibility. For those sites that did commit to a level of accessibility the practice often fell short". This highlights the need for public sector development teams to include similar user testing, which was completed during the research, when developing their websites.

Overall the study showed that accessibility was still an issue that some public-sector websites struggled with, the research was comprehensive but could be further improved by comparing their results with previous accessibility studies thus emphasising the progress (or lack of) that has been achieved over the years which could have been used as a strong argument in improving these websites.

As the development of mobile applications was mentioned in the study, it was a good opportunity to complete some real user testing on these applications with the view to stressing the major barriers regarding accessibility. The study had a unique opportunity to influence the development of public sector mobile applications just when the development of these applications was in its infancy.

2.5.2 EU Countries eGovernment Websites

In 2014 a research report was published by the NDA and the Department of Communications, Energy and Natural Resources (Laurin et al. 2016) which examined the

current state of accessibility of 37 websites from across 7 different EU countries. Much like previous research into web accessibility the study conducted both evaluation of the websites and interviews with personnel of the organisations involved. The research was conducted with the recently evoked EU directive on Accessibility in mind.

The study tested the websites based on the WCAG 2.0 guidelines success criteria. From the 37 websites tested not one was fully compliant with the WCAG 2.0 but the researchers noted that the majority would be compliant with minor amendments.

The study was well thought out with the researchers assessing the same type of websites across 7 EU countries, thus comparing like with like. They assessed the following services across the chosen countries, income tax, job search, social welfare benefits, public libraries, enrolment in college and health related services. This was good rationale for the study as this approach highlights how citizens across the EU face different issues with accessibility while trying to access the same type of services.

While the evaluation of websites was conducted on sites from 7 different countries (Ireland, Germany, Sweden, Greece, Spain, Lithuania and the UK), interviews were only conducted on personnel from 3 of these countries (Ireland, Sweden and Germany). The study could have been enhanced by performing interviews from all participating countries especially the countries where accessibility has been lacking in the past. A study by Basdekis, Klironomos, Metaxas and Stephanidis (Basdekis et al. 2009) found in 2008 over 85% of Greek e-Government sites failed the WCAG A level standard and there had been a worsening of accessibility between 2004 and 2008 across the sites. It would have been interesting to learn if the Greek economic crisis had an impact on the teams involved in developing the websites regarding accessibility and its importance.

Even though this study was conducted in 2014 there is very little reference to mobile applications or mobile devices which in 2014 would have been well established technology. The study could have benefitted from addressing the growing number of European citizens which would access the sites tested from mobile devices and included this in their study.

The interviews conducted by the researches on personnel working in public bodies were interesting in that it demonstrated that providing accessible websites was viewed necessary due to legislation rather than universal design and developing for accessibility being a natural part of the design and development life cycle. The interviews revealed that the importance of providing web accessibility has been well established compared to previous studies.

Overall, the study showed in 2014 “that much work has to be done before the websites covered in the proposed Directive to meet the requirements of WCAG 2.0 level AA”. The researchers enforce this finding by noting that only 37 websites that covered 6 services were included in their research and concluded that most if not all public services websites are not well placed for the upcoming EU Directive.

2.5.3 Accessibility of E-Government Mobile Applications.

In 2015, Serra, Carvalho, Ferreira, Viz and Ferire (Serra et al. 2015) conducted research into the accessibility of e-Government mobile applications in Brazil. The study involved an accessibility audit on four e-Government sites on both android and iOS platforms. Much like previous studies completed on web accessibility the audit was validated against the WCAG 2.0 success criteria, as the researchers noted that “Web Content Accessibility Guidelines (WCAG 2.0), have provided well-established means to audit the accessibility of websites, no such official and well-established set of guidelines has been defined for auditing the accessibility of mobile applications”, the same situation regarding guidelines is still in place today but the W3C are working on producing guidelines for mobile applications.

Much like research conducted by the NDA, the study reinforces the importance of digital inclusion for all citizens and the legal obligation on Governments to provide such services, law in Brazil states that Government services should be accessible to people with disabilities.

The study found that none of the four applications were WCAG 2.0 compliant at any level. It is not stated in the paper the level of WCAG 2.0 compliance across e-Government websites in Brazil so this creates an uncertainty if the lack of compliance was specifically related to the mobile applications development or a culture of development without accessibility in mind. The researches perceived the lack of compliance was possibly due to the omission of mobile applications on any of the accessibility legislation in Brazil.

An interesting observation of the study was the difference of accessibility between the two tested platforms, iOS and android. The research found despite having similar functionality applications tested on an android platform violated more WCAG guidelines than when tested on an iOS platform.

The finding that applications tested on an iOS platform had less accessibility issues than their android version would reinforce the reason why a survey conducted by WebAim (WebAim 2015) found that 69.9% of respondents used a device with an iOS operating

system. The data shows the iOS devices (iPad, iPhone and iPod) were the most popular used mobile devices amongst people which accessibility may be an issue.

The evaluations of the mobile applications were conducted on two mobile devices, an iPhone 5 (iOS) and a Samsung S4 (Android), both devices are phones, the study may of be aided further by the inclusion of a tablet device such as an iPad or Samsung Galaxy Tab to see if the different screen sizes had any impact on the accessibility assessment.

The study concluded with the need to create specific accessibility guidelines for mobile applications and with the necessity for mobile application accessibility to be stated in current and future legislation.

2.5.4 Disability Groups and Older People

In their research paper Díaz-Bossini and Moreno (Díaz-Bossini and Moreno 2014) focused on the accessibility of mobile application interfaces for older people and the accessibility tools available to enhance and improve their interaction with mobile applications.

The research recognises that society is ageing and "As society ages, the likelihood of people suffering some disability grows" (Díaz-Bossini and Moreno 2014), therefore increasing the importance of web and mobile accessibility. It is noted in the research that the lack of mobile guidelines from W3C and the absence of legislation has an impact on development and states that "Accessibility issues should be a requirement for developers" (Díaz-Bossini and Moreno 2014) and included throughout the development lifecycle.

The purpose of the study was to evaluate three accessibility applications against a set of guidelines from three different sources; The barriers common to Mobile Device Users and People with Disabilities produced by W3C, android accessibility guidelines, produced by google and Age-centred Research Based Web Design Guidelines produced by Panayiotis, Z. et al.

The evaluation of the tools was conducted by an accessibility expert and found that the accessibility app, Big Launcher, was from the tools evaluated, more suitable for the needs of older mobile application users.

The study was limited to android tools working on an android platform and inclusion of apple accessibility tools on iOS platforms would have given the research more validity. Another area which the research would have benefited, was testing the tools under consideration against several mobile applications and comparing the results.

Recent research under taken in the US by Wentz, Pham and Tressler (Wentz, Pham and Tressler 2017) surveyed blind users about the usability and accessibility of online and mobile banking systems. The research states that due to their disability that "there is a higher likelihood that individuals who are blind might be conducting (or desiring to conduct) a majority of their personal banking or other financial tasks with a computer or mobile device, compared to the general population" (Wentz, Pham and Tressler 2017), this infers that blind or visually impaired members of the population are also more likely to engage in public services online, increasing the importance of making these online services, either web based or mobile applications, accessible.

The researches also note they did not perceive much difference between the results from the survey about the accessibility of financial systems and other web sites and mobile applications, this would have been validated further by a related question in the questionnaire.

The research shows that 85% of respondents access financial systems using a mobile device or tablet and 35% doing so through a mobile application.

The research demonstrates the importance of developing with accessibility in mind with 76% of respondents having to ask for help when using these web pages/mobile applications.

The major reason which hindered the accessibility of the web pages and mobile applications was the interaction between the screen readers and the interface, leaving users unsure which buttons to select and the amount they had entered.

The survey respondents thought that "better labeling, improved navigation, accessible security/logo" (Wentz, Pham and Tressler 2017) would increase the accessibility of the web pages and mobile applications.

This research enforces the need for accessible web pages and mobile applications and this can be applied to Government departments and public agencies who like financial institutions are increasing moving services online. A respondent from the survey stated "I think it is crucial for financial institutions to be able to provide accessible platforms to those who are visually impaired. Personal finance is an important and private aspect of life that everyone needs access to, regardless of their disability. I wish it was easier to communicate with these institutions to be able to implement accessibility features into their mobile and online banking products." (Wentz, Pham and Tressler 2017). This statement can easily be applied to public services.

3 Methodology and Fieldwork

3.1 Research Philosophy and Methodology

Saunders et al. (Saunders et al. 2012) describe research philosophy as “to the development of knowledge and the nature of that knowledge”. At every stage of the research process, researches must make assumptions and it is vital for the research under consideration that these assumptions are understood and how they influence the questions, methods and findings of the research. According to Rubin and Rubin (Rubin and Rubin 2005) the research philosophy chosen allows the researchers to explain the choice for methods used and offers certain standards to evaluate the quality of research. Research philosophy has several different branches including ontology, axiology and epistemology. Figure 3.1 below displays the research onion which Saunders et al. developed to explain research design. Research design requires researchers to consider each layer of the research onion (Saunders et al., 2012). Researchers must consider all the outer layers of the research onion before data collection and data analysis can occur.

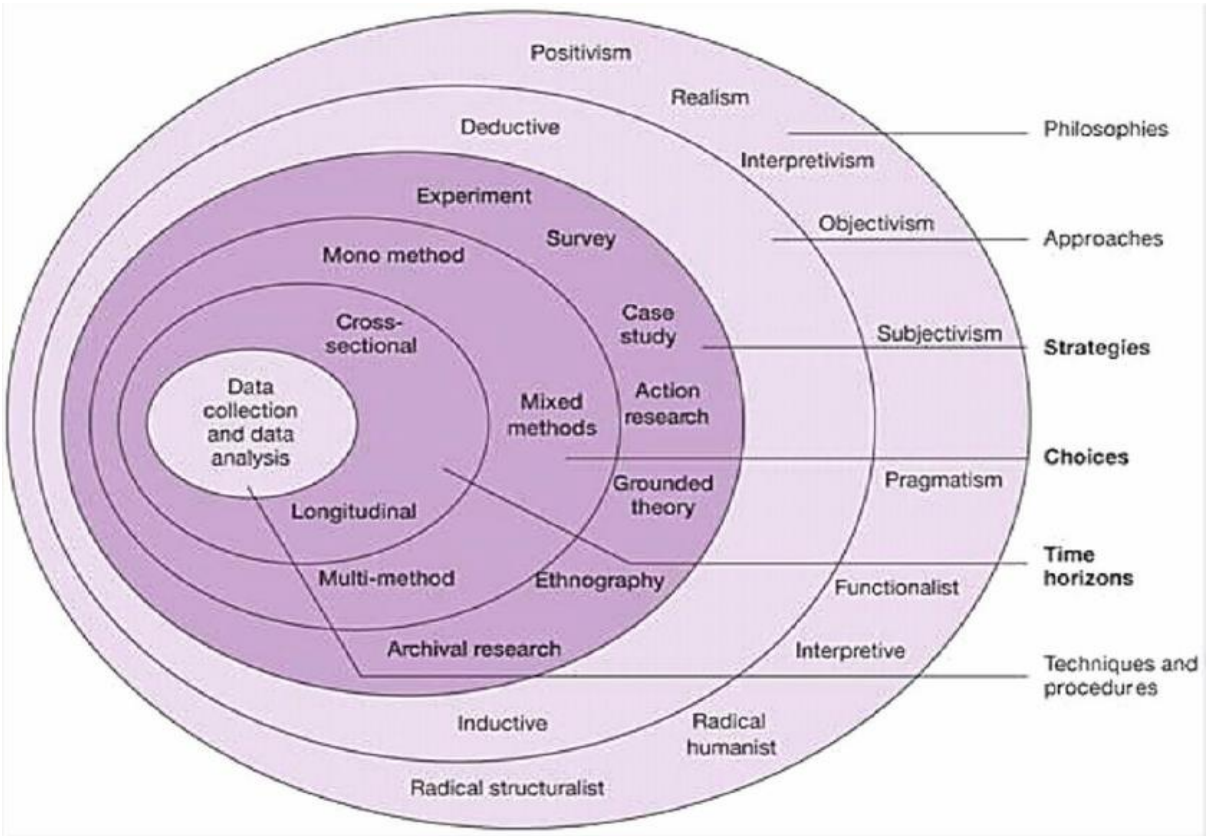


FIGURE 3.1: The research onion (Saunders et al., 2012).

According to D. M. Levin (Levin 1988) a research philosophy is a belief about the way in which data about a phenomenon should be gathered, analysed and used. The decision as to which philosophy is employed for research has enormous effects on a study. It helps determine a methodology and design of the research according to Saunders et al, (Saunders et al. 2009).

Galliers (Galliers 1991) states that two major research philosophies have been identified in the western tradition of science, called positivism and Interpretivism.

3.1.1 Positivism

Positivists think that reality is stable and can be observed and explained from an objective viewpoint (Levin 1988), i.e. without intervening with the phenomena under research.

Positivist research has the opinion that knowledge is measurable, objective and objectively understandable. According to Morgan (Morgan 1983) study in the positivist paradigm has the tendency to be statistical, mathematical and focuses on discovering trends with a sample population and relationships between social phenomena.

"Positivism has a long and rich historical tradition. It is so embedded in our society that knowledge claims not grounded in positivist thought are simply dismissed as ascientific and therefore invalid" (Hirschheim 1985).

Positivists prefer working with an observable social reality and that the end product of such research is law like generalisations similar to those produced by physical and natural scientists (Saunders et al. 2009)

David Gray (Gray 2009) implies that the “results of research will tend to be presented as objective facts and established truths. However, no theory can ever be proved simply by multiple observations, since only one instance that refutes the theory would demonstrate it as false. Hence, with the deductive approach, theories are tested through observation, leading either to falsification and discarding of the theory, or to the creation of, as yet, unfalsified laws”.

Positivism philosophy was selected for this research as the research is purely objective and independent.

3.1.2 Interpretivism

According to Neuman (Newman 2000), the goal of interpretivist research is to understand and interpret the meanings in human behaviour rather than to generalize and predict causes and effects.

Carson et al (Carson et al. 2001) asserts that interpretivists avoid inflexible structural frameworks such as used in positivist research and adopt a more flexible and personal approach to research structures which are open to capturing meanings in human interaction and make sense of what is perceived as reality.

Saunders et al. (Saunders et al. 2009) state that interpretivism researchers think that experiences and background of people are core to the way they perceive truth.

"Where positivism will often view populations at a macro level, Interpretivism is focused on the micro level, or in other words the individual" Mc Adam (Blee, 2013). The interpretivism methodology approaches people not as individual entities who exist in a vacuum but who explore their world within the whole of their life context. Researchers with this worldview believe that understanding human experience is as important as focusing on explanation, prediction and control.

Scientific/Positivist		**Interpretivist/Anti-positivist**	
Laboratory Experiments		Subjective/Argumentative	
Field Experiments		Reviews	
Surveys	✓	Action Research	✓
Case Studies		Case Studies	✓
Theorem Proof		Descriptive/Interpretive	
Forecasting		Futures Research	
Simulation		Role/Game Playing	

FIGURE 3.2: A Taxonomy of Research Methodologies (Galliers 1991)

3.2 Research Methodologies

There are two approaches extracted from the above two philosophies:

3.2.1 Quantitative research

According to Babbie (Babbie 2010) "Quantitative methods emphasize objective measurements and the statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys, or by manipulating pre-existing statistical data using computational techniques. Quantitative research focuses on gathering numerical data and generalizing it across groups of people or to explain a particular phenomenon."

Quantitative research involves trying to recognize and separate specific variables within the study framework, seek correlation, relationships and causality, and attempt to control the environment in which the data is collected to avoid the risk of variables (Brians, Craig Leonard et al, 2011)

(Saunders et al. 2009) state quantitative research "is predominantly used as a synonym for any data collection technique (such as a questionnaire) or data analysis procedure (such as graphs or statistics) that generates or uses numerical data".

3.2.2 Qualitative research

(Hogan, Dolan and Donnelly, 2009) declare that "qualitative research has 'traditionally' been conducted by means of direct observation of a sample, case studies, personal 4 Approaches to Qualitative Research: Theory & Its Practical Application experiences, introspection, an examination of relevant texts, interviews, focus groups, life stories, and the researcher's own participation in the settings that she / he is researching.".

Qualitative research cannot be expressed in numerical form. Denzin and Lincoln (2005) describe qualitative research as involving "… an interpretive naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them."

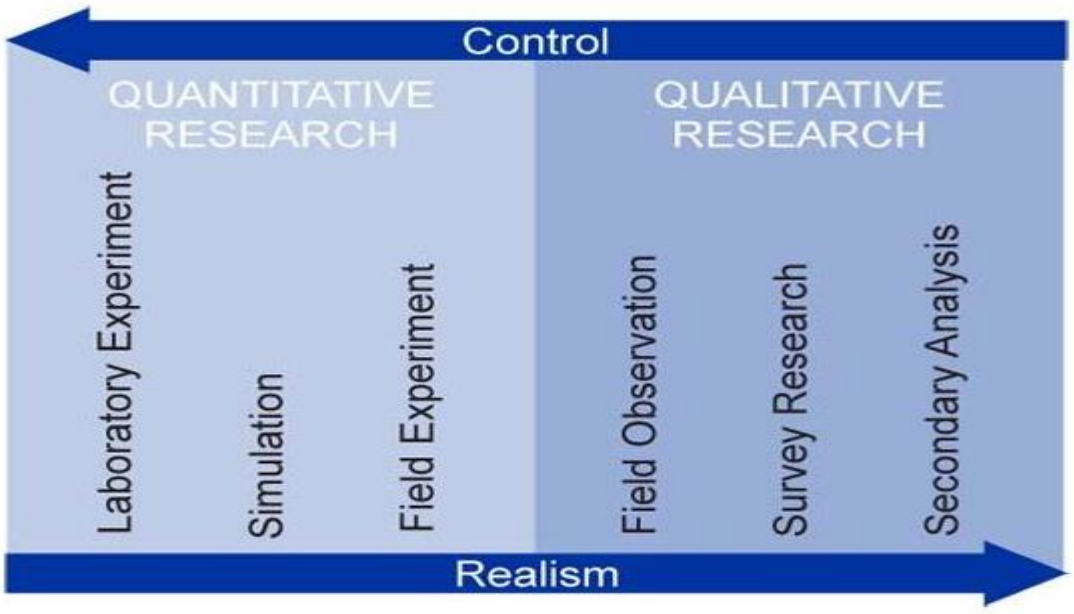


FIGURE 3.3: Control V Realism Scale Denzin and Lincoln (2005)

3.3 Research Approach

Usually the first step in academic research is to choose between two types of research reasoning, Deductive and Inductive.

3.3.1 Deductive Approach

Deductive reasoning approach according to J. Wilson (Wilson, 2010) is concerned with developing a hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis.

“Deduction approach begins with an expected pattern that is tested against observations, whereas induction begins with observations and seeks to find a pattern within them” (Babbie, 2001).

3.3.2 Inductive Approach

Inductive reasoning approach according to E. Babbie (Babbie, 2001) can be thought of as a “bottom-up” approach to building knowledge; the researcher is required to use observations and data to find patterns and regularities to develop a tentative hypothesis that will lead to general conclusion or theory.

3.4 Research Question and Objectives

The main research objective of this thesis is to create a testing framework for reusable, measurable rating of compliance in accessibility standards for government and public body applications in Ireland regarding mobile applications that are publicly available. The focus of study will seek answers to the following questions.

Q1 Do Irish Government Mobile applications comply with the WCAG 2.0 guidelines?

Q2 Are these mobile applications compliant with the EU Web Accessibility Directive?

Q3 How can the WCAG 2.0 guidelines be improved regarding mobile accessibility?

A sub-question which may be measured during the research, which involves the testing of mobile applications over different platforms is, if there is differing compliance levels between the same mobile applications on android and iOS?

By assessing and rating the mobile applications against the WCAG 2.0 guidelines, the research will give a clear indication if the mobile applications will comply with the upcoming

accessibility legislation which will be in place during September 2018 and provide the changes to make the applications compliant.

This research may also help Government departments and other public bodies, which develop and maintain public websites and mobile applications, as well as disability groups, who have a vested interest in the accessibility of these resources, in their preparation for compliance.

3.5 Research Audit

This section describes the reasoning behind the chosen testing techniques and the testing framework which structed how the research data was collected.

3.5.1 Research Method

This research uses a web accessibility audit assessment methodology procedure to collect, analyse and interpret the qualitative data.

For the accessibility audits, different approaches were considered. Based on previous studies on web accessibility of Irish Government websites (Mulvey 2008) and the accessibility of Brazilian mobile applications (Leadro Coelho Serra et al. 2015) it was deemed necessary to evaluate the chosen mobile applications against the WCAG 2.0 guidelines.

These guidelines although not mobile application specific, are written to be independent of technology and can be applied to mobile applications along with web sites.

Further enforcing the reason to evaluate the mobile applications against the WCAG 2.0 guidelines is Irish national legislation, as stated by National Disability Authority, the guidelines developed by the World Wide Web Consortium “is the only standard that is referred to within Irish Government policy (see Legislation and Public Policy for more details). WCAG 2.0 is the current version of these guidelines” (NDA 2017).

3.5.2 Testing Framework

The research was broken down into six distinct phases which reflects the different testing procedures undertaken across both the iOS and android platforms to evaluate the accessibility of the mobile applications.

The first phase involved a manual audit of the five mobile applications on an android platform against the WCAG 2.0 success criteria checklist. Each application was first

checked for Level A conformance, if passed the audit checked for Level AA conformance and finally if Level AA was achieved, the audit checked for Level AAA conformance.

The second phase involved a manual audit of the five mobile applications on an iOS platform against the WCAG 2.0 success criteria checklist. Each application was first checked for Level A conformance, if passed the audit checked for Level AA conformance and finally if Level AA was achieved, the audit checked for Level AAA conformance.

The manual audit was completed and the results achieved, on the five mobile applications across both platforms can be found in appendix.

The third phase involved testing the five applications on an android platform for accessibility using google own accessibility tool.

The fourth phase involved testing the five applications on an iOS platform for accessibility using an accessibility tool produced by apple.

The fifth phase involved a manual assessment of the five mobile applications using android's inbuilt screen reader, Talkback.

The sixth phase involved a manual assessment of the five mobile applications using apple's inbuilt screen reader, VoiceOver.

3.5.3 Testing Hardware

Research for the android testing phase was conducted on a 7" Lenovo tablet with android version 6.0 operating system, also known as marshmallow.

Research for the iOS testing phase was conducted 9.7" Apple Ipad with iOS 10 operating system.

These devices were chosen due to cost issues.

The screen size of the testing devices and the impact that this may have on accessibility was deemed outside the scope of this research. This was due to the vast amount of different screen sizes available on mobile phones, tablets etc. To perform accessibility audits on every screen size would involve many months of work and is one of the many problems facing mobile application developers and testers (Android 2017)

As most of the public bodies mobile applications in the research population have been developed and released since 2015, it was considered necessary that testing should only be conducted on devices with newer operating systems which have been available from 2015 onwards. To conduct the research on the many operating systems that android and iOS

support would once again involve many months of work, therefore, testing of the mobile applications for accessibility across multiple operating systems on both iOS and android was judged to be outside the scope of this research.

Android operating system 6.0 (marshmallow) was released in October 2015 (Android 2017).

iOS operating system 10 was released in September 2016 (Apple 2017).s

3.6 Research Population

Sampling is usually necessary during the research process as collecting data from a whole population could be unreasonable in terms of cost, time and human involvement. As sampling is to vital in research it is necessary that an appropriate sampling technique is used to ensure the research finding are as accurate as possible.

Saunders et al. (Saunders et al. 2003) separated sampling techniques into probability sampling and non-probability sampling. In probability sampling all components of the research population have a chance to be included in the research, whereas in non-probability sampling, the components have a known chance of being included in the research.

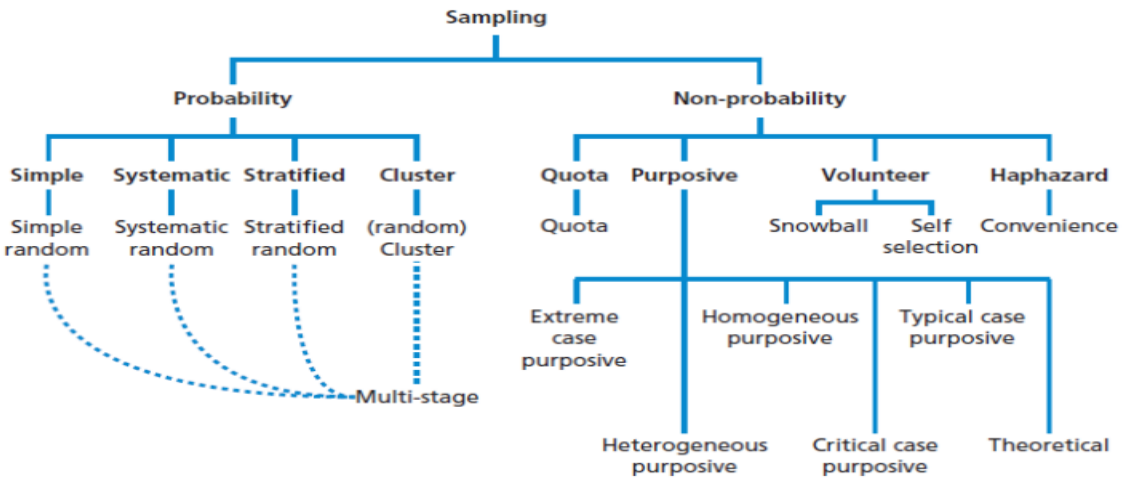


FIGURE 3.4: Categories of Sampling Techniques (Saunders et al. 2003)

The research population considered for this dissertation was mobile applications developed by Irish Government departments and Public Bodies which are available on both android and iOS. To be included in the research the mobile applications must work on both platforms. Also, under consideration were websites which have been specifically designed to work on mobile platforms.

A sample size of five mobile applications was selected based on previous research done on web accessibility by Mulvey (Mulvey, 2008) and mobile application accessibility done by Serra et al. (Serra et al. 2015) both studies choose a sample size of four to five. This research also only included mobile applications which worked on both iOS and android platforms.

Once a suitable sample size was selected a simple randoming technique was used for test case selection. This technique ensured that "each individual is chosen entirely by chance, and each member of the population has an equal chance of being included in the sample." (Duigan, 2016).

3.7 Research Ethics

Ethics are the standards of behaviour that guide the researcher's interaction with participants and the respect for the rights of the participant and those impacted by the research (Saunders et al., 2012).

As the research under consideration consisted of the testing of mobile applications which are freely available in the public domain and did not involve human involvement or interaction and no personal information or views was collected, ethic approval was not necessary.

No ethical issues arose during the timeframe of the research. The tester of the mobile applications was able bodied with no disabilities. It was decided not to use people with disabilities during the research to reflect the reality of personnel working on development and testing teams which produce the mobile applications.

3.8 Lessons Learned

Several different issues were encountered during the research and the testing of the mobile applications, which had an impact on time but not on the overall quality and reliability of the research.

Despite advertising that apps were available on both android and iOS platforms, several applications which were chosen for testing were either not available on iOS or had been removed from both platforms since the research population selection and testing had begun.

Testing of the Passport Card application from the Department of Foreign Affairs had begun in March/April 2017. When research was continued in June 2017 on the 7" tablet, the app had been removed from both the android and apple stores so this application had to be removed from the research.

The mobile application accessibility testing market is not yet mature so no tool was available, either opensource or for sale, for the testing of both android and iOS together. This was confirmed by checking the web accessibility tool list on the W3C website (W3C, 2017). A search for a tool which assists in mobile accessibility returned two results, a tool that evaluates browsers on mobile phones and an iOS tool. Neither tool was deemed suitable for this research. Both Google and Apple have their own tools which assist developers in producing accessible applications, as the research is assessing finished applications, neither of these tools were suitable to assist in the testing phase of the research.

Some third party open source applications were researched to aid the testing of applications on both android and iOS platforms, these included Accessibility Scanner (Android), Colour Checker (Android), Contrast Checker (iOS) and Userlight (iOS). The amount of open source accessibility tools reflected the market of Android V iOS with more applications available for testing android applications.

It was hoped that Accessibility Scanner and Userlight could be used in conjunction with each other but Userlight could only be used with the source code which was deemed out of scope of this research.

Good industry practice dictates that accessibility testing also needs to be completed manually by an accessibility expert and this was also completed during the research and was considered very important due to the cross comparison needed on the iOS and android platforms.

The screen readers used during the testing of the mobile applications, voice over and talkback, required comprehensive training which included online and practical tutorials. This task involved five days training and was deemed necessary for the research to be complete and due to the lack of tools available.

3.9 Functionality of Tested Mobile Applications

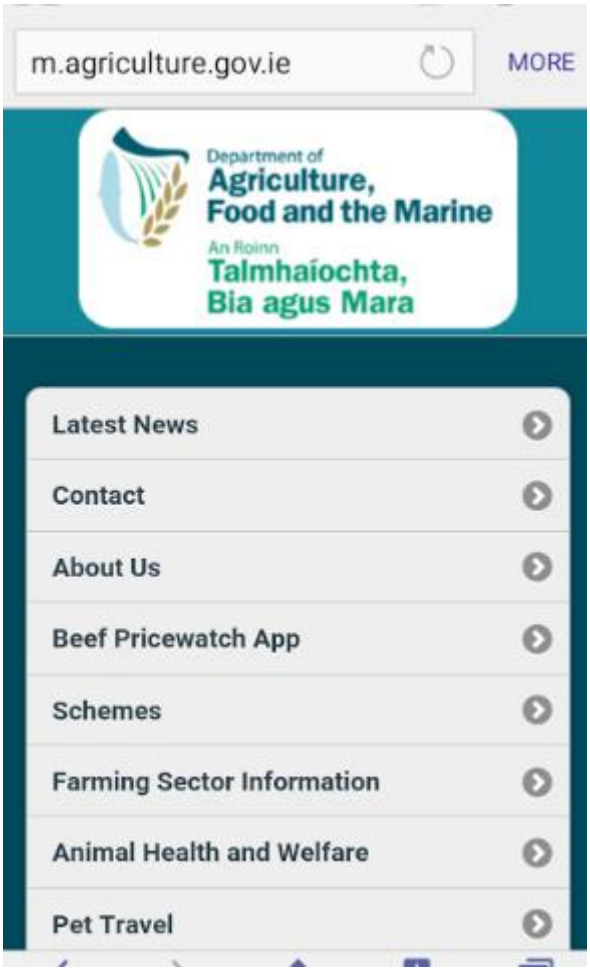
The testing of five public bodies mobile applications on both Android and iOS platforms will help establish the accessibility issues on these applications and if WCAG 2.0 guidelines are being adhered too. The applications tested will include both native and web applications thus further ensuring testing of accessibility. Identifying the common accessibility issues which prevent mobile applications being accessible is a step towards finding solutions and answering the research questions concerning this dissertation "What are the common issues preventing mobile application accessibility?" and "Do Government mobile applications comply with the WCAG 2.0 guidelines?". The five mobile applications tested were; The Department of Agriculture, Food and the Marine (web app), Revenue Online Services (native app), Department of Foreign Affairs and Trade – TravelWise Ireland (native app) and Department of Transport – Real Time (native app). These mobile applications were chosen as a board representative of Government Departments and public bodies. During the research stage, it was discovered not all Government Departments or Public Bodies have engaged with mobile application development. The next sections give a brief description of each departments functions and the intended functionality of the mobile applications.

3.9.1 Department of Agriculture, Food and the Marine – Mobile Website.

As stated on their website (DAFM 2016) "The Department's mission is to lead the sustainable development of the agri-food, forestry and marine sector and to optimise its contribution to national economic development and the natural environment." The Department is also responsible for the payment of common agriculture policy (CAP) and common fisheries policy (CFP) monies from the EU. The Department has strong online interaction with its customers with most Single Farm Payments (SFP) applications now done online.

The Department launched its mobile website in 2012, it can be accessed at http://m.agriculture.gov.ie/ and as stated on e.gov.ie (Gov.ie 2013) the site aims to provide "better mobile access to the more popular areas of the main website. The service is designed to work better across a range of modern mobile devices and will provide links into the main website when greater detail is required."

In their Accessibility statement on the main website (DAFM 2017) the Department state that they are committed to achieving AA or AAA rating based on WCAG 1.0 on all new content published.



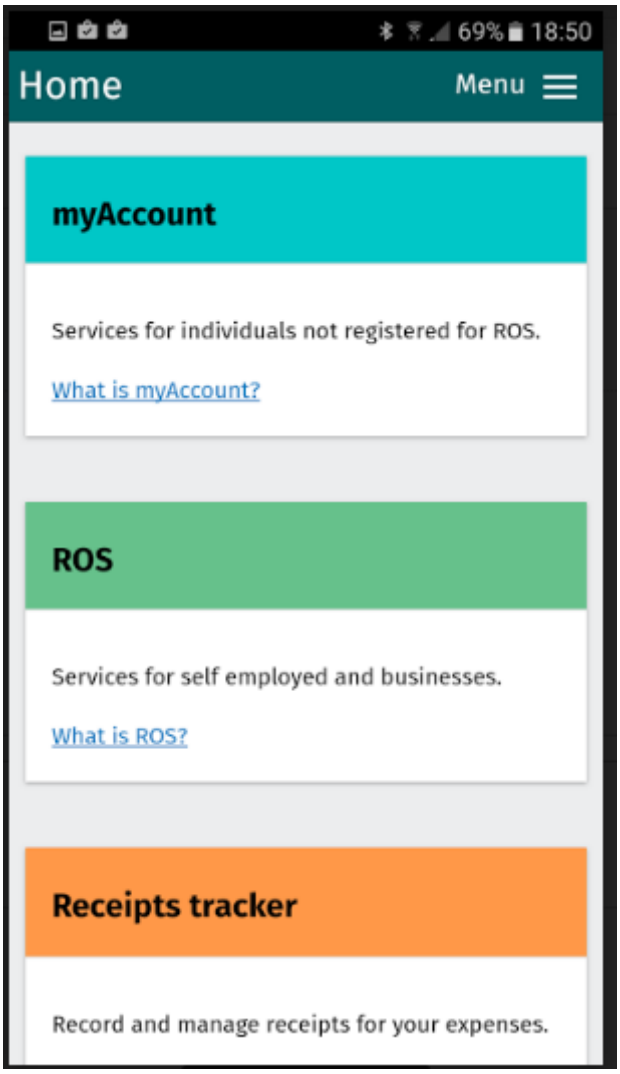
DAFM Website on Android

3.9.2 Revenue Commissioners – RevApp

The Office of the Revenue Commissioners is the primary state body responsible for the assessment and collection of taxes and duties in the Republic of Ireland. Revenue has a very strong online presence with individuals and businesses able to conduct tax affairs online through ROS (Revenue Online Services) and PAYE anytime. RevApp was launched late 2016 and is available to download for free for both iOS and Android. RevApp aims to help people manage their tax affair on the go and offers mobile access to MyAccount, ROS, calculators and tools, MyEnquires and Receipt Tracker.

In their Accessibility statement on the main website Revenue (Revenue 2017) state that they are committed to achieving "Triple-A" accessibility of the World Wide Web Consortium's

(W3C) Web Content Accessibility Guidelines 1.0. This statement relates to the current website which was launched in 2008.



RevApp on Android

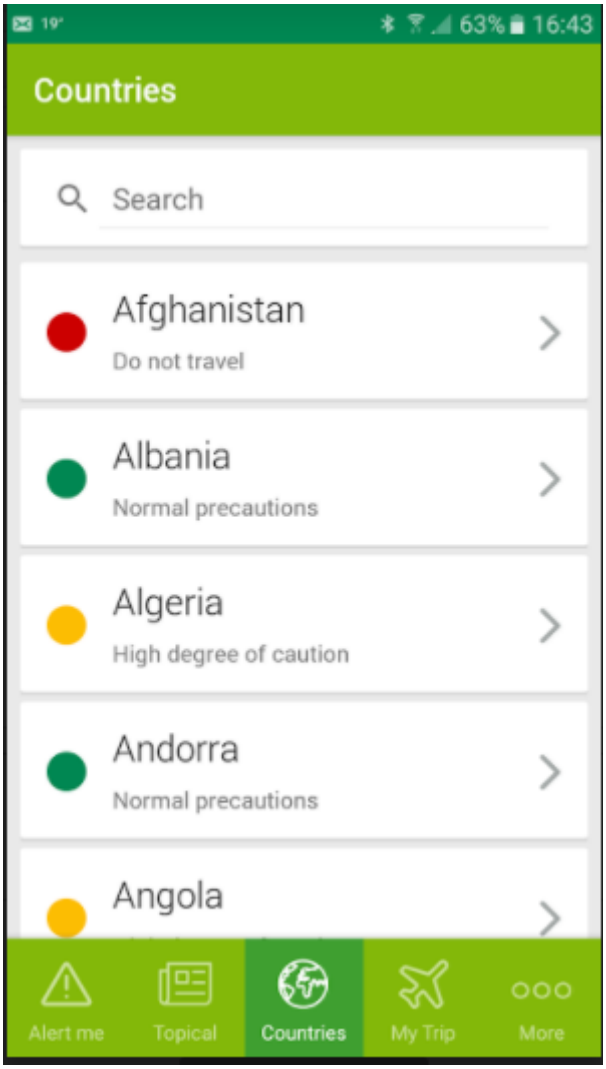
3.9.3 Department of Foreign Affairs and Trade- TravelWise Application

On their website, the Department of Foreign Affairs and Trade mission statement they declare their role as “to serve the Irish people, promote their values and advance their prosperity and interests abroad, and to provide the Government with the capabilities, analysis and influence to ensure that Ireland derives the maximum benefit from all areas of its external engagement” (DFA 2016).

TravelWise a user-friendly application, has been developed by the Department to provide trusted and comprehensive travel advice and consular information for 200 different

countries, to Irish citizens traveling to these countries to keep them informed and aware of any travel alerts.

The Department of Foreign Affairs and Trade did not have an accessibility statement on their website but state “We are committed to helping people with disabilities to access our services.” (DFA, 2016).



TravelWise on Android

3.9.4 Failte Ireland – Dublin Discovery Trails Application

Failte Ireland also known as National Tourism Development Authority has a role to "support the tourism industry and work to sustain Ireland as a high-quality and competitive tourism destination" (Failte Ireland, 2017).

The Discover Dublin Trails app which is available for both android and apple systems, gives users a series of self-guided walks around Dublin city.

Failte Ireland declare that they are committed to ensuring that all their services are accessible and state that their main website (www.failteireland.com) conforms to a AA standard of the WCAG 2.0 guidelines (Failte Ireland, 2017).

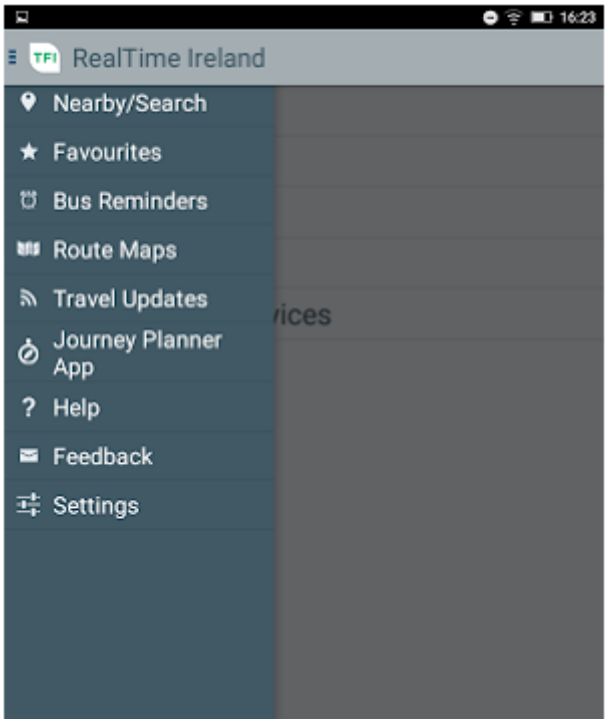
Dublin Discovery Trails on Android

3.9.5 Transport for Ireland – RealTime Application

Transport for Ireland which operates under the National Transport Authority brings together information from all public service transport agencies to enabling the public to plan trips etc. The National Transport Authority states that the “Transport for Ireland service as a “one stop shop” for public transport information” (National Transport Authority 2017.)

The RealTime app “integrates all real-time arrival information services from Dublin Bus, Bus Éireann, DART, Iarnród Éireann and Luas services.” (Transport for Ireland 2017) and is available on android and iOS.

Transport for Ireland (Transport for Ireland 2017) state that they are committed to meeting the AA standard of WCAG 2.0 guidelines along with the National Disability Authority guidelines.



RealTime App on Android

4. Findings and Analysis

4.1 Evaluation Results

Five different mobile applications were tested on both android and iOS platforms. This encompassed over 31 different pages and these pages were firstly audited against the existing WCAG 2.0 guidelines. These pages were then assessed for accessibility using the inbuilt screen readers available, Voiceover for iOS and Talkback for Android. The evaluation of the applications also included a review using a contrast checker tool.

The testing framework involved three levels of manual testing which has been supported in previous studies as the most successful way in ensuring accessibility of applications, “web accessibility requires more than just accessibility tools; it requires human judgement” (WebAIM, 2017). As the mobile application accessibility market is not mature, manual testing of the applications was considered the only way possible to assess the applications for WCAG 2.0 compliance. This manual testing involved multiple layers including contrast checking, screen reader assessment and general usability of the applications.

Overall, the results showed that none of the applications tested achieved AA compliance rating against the current WCAG 2.0 guidelines, which is the agreed compliance level that the Government has committed too and the legal requirement level from September 2018. In fact, all the applications failed to reach the minimum standard of A compliance level.

The screen reader testing and colour contrast testing shows the many accessibility issues which may impede citizens with blindness or low vision from accessing and using these applications.

One application was deemed totally unsuitable for accessibility testing as it didn’t display correctly on either the android or apple platform. These finding are displayed and examined in further detail in this chapter.

Further analysis of the results showed many common issues which arose across all applications on both platforms, such as multiple ways to locate information and the contrast minimum between text and background.

The current WCAG 2.0 guidelines were found to be too rigid in their wording to be suitably applied to mobile applications and some adaptions were necessary.

4.2 WCAG 2.0 Audit

The five applications were audited for WCAG 2.0 compliance, under each platform and the results of the audit are broken down into the different levels of compliance, A, AA and AAA. Applications would be only tested for AAA compliance if they had previously passed A and AA compliance.

4.2.1 RevApp

Level A Compliance	**RevApp Android Pages**						
Success Criterion	my Account	What is my Account	ROS	Home	Receipts tracker	My Enquiries	Calculators and tools
1.1.1 – Non-text Content	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.1 – Info and Relationships	N/A	N/A	N/A	PASS	N/A	N/A	N/A
1.3.2 – Meaningful Sequence	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1.3.3 – Sensory Characteristics	PASS	PASS	N/A	PASS	FAIL	FAIL	FAIL
1.4.1 – Use of Colour	PASS	N/A	PASS	N/A	N/A	N/A	N/A
1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.4.1 – Bypass Blocks	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.2 – Page Titled	PASS	PASS	FAIL	PASS	FAIL	FAIL	FAIL
2.4.3 – Focus Order	PASS	N/A	N/A	PASS	N/A	N/A	N/A
2.4.4 – Link Purpose (In Context)	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.1.1 – Language of Page	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.2.1 – On Focus	PASS	N/A	N/A	PASS	N/A	N/A	N/A
3.2.2 – On Input	PASS	N/A	N/A	N/A	N/A	N/A	N/A
3.3.1 – Error Identification	PASS	N/A	N/A	N/A	N/A	N/A	N/A
3.3.2 – Labels or Instructions	FAIL	N/A	N/A	PASS	N/A	N/A	N/A
4.1.1 – Parsing	PASS	PASS	PASS	PASS	PASS	PASS	PASS
4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Level AA Compliance	my Account	What is my Account	ROS	Home	Receipts tracker	My Enquiries	Calculators and tools
1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.3 – Contrast (Minimum)	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1.4.4 – Resize text	PASS	FAIL	PASS	FAIL	PASS	PASS	PASS
1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
2.4.6 – Headings and Labels	PASS	PASS	PASS	FAIL	PASS	PASS	PASS
2.4.7 – Focus Visible	PASS	N/A	N/A	N/A	N/A	N/A	N/A
3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.3 – Consistent Navigation	PASS	PASS	FAIL	PASS	FAIL	FAIL	FAIL

3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.3.3 – Error Suggestion	PASS	N/A	N/A	N/A	N/A	N/A	N/A
3.3.4 – Error Prevention (Legal, Financial, Data)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

FIGURE 4.1: RevApp Android WCAG 2.0 Audit Results

Level A Compliance	**RevApp IOS Pages**						
Success Criterion	my Account	What is my Account	ROS	Home	Receipts tracker	My Enquiries	Calculators and tools
1.1.1 – Non-text Content	N/A	PASS	N/A	N/A	N/A	N/A	N/A
1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.1 – Info and Relationships	PASS	PASS	N/A	PASS	N/A	N/A	N/A
1.3.2 – Meaningful Sequence	PASS	PASS	N/A	PASS	N/A	N/A	N/A
1.3.3 – Sensory Characteristics	FAIL	PASS	PASS	FAIL	PASS	PASS	PASS
1.4.1 – Use of Colour	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.1 – Bypass Blocks	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.4.2 – Page Titled	PASS	PASS	FAIL	PASS	FAIL	FAIL	FAIL
2.4.3 – Focus Order	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.4 – Link Purpose (In Context)	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.1.1 – Language of Page	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.1 – On Focus	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.2 – On Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.1 – Error Identification	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.2 – Labels or Instructions	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Level AA Compliance	my Account	What is my Account	ROS	Home	Receipts tracker	My Enquiries	Calculators and tools
1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.3 – Contrast (Minimum)	PASS	FAIL	PASS	FAIL	PASS	PASS	PASS
1.4.4 – Resize text	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
2.4.6 – Headings and Labels	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.7 – Focus Visible	PASS	N/A	N/A	N/A	N/A	N/A	N/A
3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.3 – Consistent Navigation	FAIL	FAIL	PASS	PASS	PASS	PASS	FAIL
3.2.4 – Consistent Identification	PASS	N/A	PASS	PASS	PASS	PASS	PASS

3.3.3 – Error Suggestion	FAIL	N/A	N/A	N/A	N/A	N/A	N/A
3.3.4 – Error Prevention (Legal, Financial, Data)	N/A	N/A	N/A	N/A	N/A	N/A	N/A

FIGURE 4.2: RevApp iOS WCAG 2.0 Audit Results

The results show that the RevApp fails to reach A compliance on both iOS and android platforms. When further analysed the results show common failures across the both platforms with pages lacking titles and links, buttons etc lacking information on what to do next.

When examined for AA compliance the application failed on many levels across both platforms, with consistent navigation across the pages and multiple ways to search within the app being the most noticeable.

The app also failed on contrast minimum across both platforms and this is further analysed in section 4.3.1.

The resizing of text up to 200% also was problematic on many pages.

The results of the WCAG 2.0 audit shows that the RevApp has not reached the acceptable standard of AA compliance.

4.2.2 Department of Agriculture, Food and the Marine – Mobile Website

Pages Legend: 1 Home, 2 Latest News, 3 Contact, 4 About Us, 5 Schemes, 6 Farming Sector Info, 7 Animal Health and Welfare, 8 Pet Travel, 9 Fisheries, 10 Forestry, 11 Cookie Usage

Level A Compliance	Agriculture Mobile Site Android										
Success Criterion	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1.1.1 – Non-text Content	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.1 – Info and Relationships	N/A	N/A	PASS	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.2 – Meaningful Sequence	PASS	N/A	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.3 – Sensory Characteristics	PASS	PASS	FAIL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.1 – Use of Colour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.4.1 – Bypass Blocks	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.2 – Page Titled	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2.4.3 – Focus Order	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.4 – Link Purpose (In Context)	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.1.1 – Language of Page	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.2.1 – On Focus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.2 – On Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.1 – Error Identification	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.2 – Labels or Instructions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Level AA											
1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.3 – Contrast (Minimum)	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
1.4.4 – Resize text	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
2.4.6 – Headings and Labels	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.7 – Focus Visible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

3.2.3 – Consistent Navigation	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.3.3 – Error Suggestion	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.4 – Error Prevention (Legal, Financial, Data)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

FIGURE 4.3: DAFM Android WCAG 2.0 Audit Results

Level A	Agriculture Mobile Site IOS										
Success Criterion	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1.1.1 – Non-text Content	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.1 – Info and Relationships	N/A	N/A	PASS	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.2 – Meaningful Sequence	PASS	N/A	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.3 – Sensory Characteristics	PASS	PASS	FAIL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.1 – Use of Colour	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.1 – Bypass Blocks	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.2 – Page Titled	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2.4.3 – Focus Order	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.4 – Link Purpose (In Context)	PASS	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.1.1 – Language of Page	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.2.1 – On Focus	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.2 – On Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.1 – Error Identification	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.2 – Labels or Instructions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Level AA											
1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.3 – Contrast (Minimum)	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
1.4.4 – Resize text	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
2.4.6 – Headings and Labels	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.4.7 – Focus Visible	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.3 – Consistent Navigation	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.3.3 – Error Suggestion	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.3.4 – Error Prevention (Legal, Financial, Data)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

FIGURE 4.4: DAFM iOS WCAG 2.0 Audit Results

The results show that the Department of Agriculture, Food and Marine's mobile website does not pass A or AA compliance level so was not tested for AAA compliance.

Common issues appear across the mobile application on both android chrome and iOS safari with the lack of information and purpose on links, and pages without titles being identified as barriers to achieving A compliance.

When checked for AA compliance both platforms failed on, multiple ways to search and contrast minimum, the failure on contrast minimum will be analysed further in section 4.3.2.

The results of the WCAG 2.0 audit shows that the DAFM mobile website has not reached the acceptable standard of AA compliance.

Overall, with a few minor adjustments as discussed above, the mobile website should be able to achieve AA compliance by September 2018.

4.2.3 TravelWise App

	Travel Wise App Android Pages				
Level A Compliance	Alert Me	Topical	Countries	My Trip	More
Success Criterion 1.1.1 – Non-text Content	N/A	PASS	N/A	N/A	N/A
Success Criterion 1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.3.1 – Info and Relationships	N/A	PASS	N/A	N/A	N/A
Success Criterion 1.3.2 – Meaningful Sequence	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.3.3 – Sensory Characteristics	PASS	PASS	PASS	PASS	PASS
Success Criterion 1.4.1 – Use of Colour	PASS	N/A	FAIL	N/A	N/A
Success Criterion 1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.1 – Bypass Blocks	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.2 – Page Titled	PASS	PASS	PASS	PASS	PASS
Success Criterion 2.4.3 – Focus Order	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.4 – Link Purpose (In Context)	N/A	N/A	N/A	N/A	PASS

Success Criterion 3.1.1 – Language of Page	PASS	PASS	PASS	PASS	PASS
Success Criterion 3.2.1 – On Focus	N/A	N/A	PASS	N/A	N/A
Success Criterion 3.2.2 – On Input	N/A	N/A	PASS	N/A	N/A
Success Criterion 3.3.1 – Error Identification	N/A	N/A	FAIL	N/A	N/A
Success Criterion 3.3.2 – Labels or Instructions	N/A	N/A	FAIL	N/A	N/A
Success Criterion 4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A
Success Criterion 4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A
Level AA Compliance	Alert Me	Topical	Countries	My Trip	More
Success Criterion 1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.4.3 – Contrast (Minimum)	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 1.4.4 – Resize text	PASS	FAIL	PASS	PASS	PASS
Success Criterion 1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 2.4.6 – Headings and Labels	PASS	PASS	PASS	PASS	PASS
Success Criterion 2.4.7 – Focus Visible	PASS	N/A	N/A	N/A	N/A
Success Criterion 3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A
Success Criterion 3.2.3 – Consistent Navigation	PASS	PASS	PASS	PASS	PASS
Success Criterion 3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS
Success Criterion 3.3.3 – Error Suggestion	N/A	N/A	FAIL	N/A	N/A
Success Criterion 3.3.4 – Error Prevention (Legal, Financial, Data)	N/A	N/A	N/A	N/A	N/A

FIGURE 4.5: TravelWise Android WCAG 2.0 Audit Results

	Travel Wise App IOS Pages				
Level A Compliance	Alert Me	Topical	Countries	My Trip	More
Success Criterion 1.1.1 – Non-text Content	N/A	PASS	N/A	N/A	N/A
Success Criterion 1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.3.1 – Info and Relationships	N/A	PASS	N/A	N/A	N/A
Success Criterion 1.3.2 – Meaningful Sequence	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.3.3 – Sensory Characteristics	PASS	FAIL	FAIL	PASS	FAIL
Success Criterion 1.4.1 – Use of Colour	N/A	N/A	FAIL	N/A	N/A
Success Criterion 1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.1 – Bypass Blocks	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.2 – Page Titled	PASS	PASS	PASS	PASS	PASS
Success Criterion 2.4.3 – Focus Order	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.4 – Link Purpose (In Context)	N/A	N/A	N/A	N/A	PASS
Success Criterion 3.1.1 – Language of Page	PASS	PASS	PASS	PASS	PASS

Success Criterion 3.2.1 – On Focus	N/A	N/A	PASS	N/A	N/A
Success Criterion 3.2.2 – On Input	N/A	N/A	PASS	N/A	N/A
Success Criterion 3.3.1 – Error Identification	N/A	N/A	FAIL	N/A	N/A
Success Criterion 3.3.2 – Labels or Instructions	N/A	N/A	FAIL	N/A	N/A
Success Criterion 4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A
Success Criterion 4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A
Level AA Compliance	Alert Me	Topical	Countries	My Trip	More
Success Criterion 1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.4.3 – Contrast (Minimum)	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 1.4.4 – Resize text	PASS	PASS	PASS	PASS	PASS
Success Criterion 1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 2.4.6 – Headings and Labels	PASS	PASS	PASS	PASS	PASS
Success Criterion 2.4.7 – Focus Visible	PASS	N/A	N/A	N/A	N/A
Success Criterion 3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A
Success Criterion 3.2.3 – Consistent Navigation	PASS	PASS	PASS	PASS	FAIL
Success Criterion 3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS
Success Criterion 3.3.3 – Error Suggestion	N/A	N/A	FAIL	N/A	N/A
Success Criterion 3.3.4 – Error Prevention (Legal, Financial, Data)	N/A	N/A	N/A	N/A	N/A

FIGURE 4.6: TravelWise iOS WCAG 2.0 Audit Results

The results show that the TravelWise app does not pass A or AA compliance level so was not tested for AAA compliance.

The ‘Countries’ page on the app was the main source of issues which caused failure to achieve A compliance level with the use of colour, error identification and instructions being common issues across both platforms.

When checked for AA compliance both platforms failed on, multiple ways to search and contrast minimum, the failure on contrast minimum will be analysed further in section 4.3.2. Other issues which also contributed to lack of AA compliance where lack of error suggestions on the Countries page and the More page not having consistent navigation.

The results of the WCAG 2.0 audit shows that the TravelWise application has not reached the acceptable standard of AA compliance.

Overall, with a few minor adjustments as discussed above, the mobile website should be able to achieve AA compliance by September 2018.

4.2.4 Discovery Trails

A WCAG 2.0 audit was unable to be conducted on the Discovery Trails applications on both platforms due to major usability issues and the basic functionality of the application not working. The applications pages did not open fully and the content of the pages were inaccessible on the android table and apple ipad.

On the apple store, it states that the application is compatible with ipad iOS 7.0 or later. On google play store, it states it is compatible with all android devices.

This technical issue with the application not working on the chosen devices for the research, highlights the complexity of developing applications that work across multiple platforms and devices.

It also stresses the importance of testing the applications for basic functionally and usability across the multiple platforms and devices before accessibility can be tested.

4.2.5 RealTime App Audit

Real Time App Page Legend: 1 Nearby/Search, 2 Favourites, 3 Bus Reminders, 4 Route Maps, 5 Travel Updates, 6 Help, 7 Feedback, 8 Settings.

Level A Compliance	Real Time App Android							
Success Criterion	1	2	3	4	5	6	7	8
1.1.1 – Non-text Content	N/A	PASS	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.3.1 – Info and Relationships	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.3.2 – Meaningful Sequence	N/A	N/A	N/A	N/A	N/A	N/A	PASS	N/A
Success Criterion 1.3.3 – Sensory Characteristics	N/A	N/A	PASS	PASS	PASS	PASS	N/A	PASS
Success Criterion 1.4.1 – Use of Colour	PASS	PASS	PASS	FAIL	FAIL	FAIL	N/A	PASS
Success Criterion 1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Success Criterion 2.4.1 – Bypass Blocks	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.2 – Page Titled	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Success Criterion 2.4.3 – Focus Order	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.4 – Link Purpose (In Context)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 3.1.1 – Language of Page	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 3.2.1 – On Focus	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
Success Criterion 3.2.2 – On Input	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
Success Criterion 3.3.1 – Error Identification	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
Success Criterion 3.3.2 – Labels or Instructions	FAIL	N/A	FAIL	N/A	N/A	N/A	FAIL	N/A
Success Criterion 4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Level AA								
Success Criterion 1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 1.4.3 – Contrast (Minimum)	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 1.4.4 – Resize text	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
Success Criterion 2.4.6 – Headings and Labels	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 2.4.7 – Focus Visible	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
Success Criterion 3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Success Criterion 3.2.3 – Consistent Navigation	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS

Success Criterion 3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
Success Criterion 3.3.3 – Error Suggestion	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
Success Criterion 3.3.4 – Error Prevention (Legal, Financial, Data)	FAIL	N/A	N/A	N/A	N/A	N/A	FAIL	N/A

FIGURE 4.7: RealTime Android WCAG 2.0 Audit Results

Level A Compliance	Real Time App IOS							
Success Criterion	1	2	3	4	5	6	7	8
1.1.1 – Non-text Content	N/A	PASS	N/A	N/A	N/A	N/A	N/A	N/A
1.2.1 – Audio-only and Video-only (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.2 – Captions (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.3 – Audio Description or Media Alternative (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.1 – Info and Relationships	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.3.2 – Meaningful Sequence	N/A	N/A	N/A	N/A	N/A	N/A	PASS	N/A
1.3.3 – Sensory Characteristics	N/A	N/A	PASS	PASS	PASS	PASS	N/A	PASS
1.4.1 – Use of Colour	PASS	PASS	PASS	FAIL	FAIL	FAIL	N/A	PASS
1.4.2 – Audio Control	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.1 – Keyboard	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.1.2 – No Keyboard Trap	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.1 – Timing Adjustable	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.2.2 – Pause, Stop, Hide	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.3.1 – Three Flashes or Below Threshold	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

2.4.1 – Bypass Blocks	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.2 – Page Titled	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
2.4.3 – Focus Order	PASS	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.4 – Link Purpose (In Context)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.1.1 – Language of Page	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.1 – On Focus	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
3.2.2 – On Input	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
3.3.1 – Error Identification	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
3.3.2 – Labels or Instructions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.1 – Parsing	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4.1.2 – Name, Role, Value	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Level AA Compliance								
1.2.4 – Captions (Live)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.2.5 – Audio Description (Prerecorded)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1.4.3 – Contrast (Minimum)	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
1.4.4 – Resize text	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
1.4.5 – Images of Text	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.5 – Multiple Ways	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
2.4.6 – Headings and Labels	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2.4.7 – Focus Visible	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
3.1.2 – Language of Parts	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3.2.3 – Consistent Navigation	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS

3.2.4 – Consistent Identification	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
3.3.3 – Error Suggestion	PASS	N/A	N/A	N/A	N/A	N/A	PASS	N/A
3.3.4 – Error Prevention (Legal, Financial, Data)	FAIL	N/A	N/A	N/A	N/A	N/A	FAIL	N/A

FIGURE 4.8: RealTime iOS WCAG 2.0 Audit Results

The results show that the RealTime app does not pass A or AA compliance level so was not tested for AAA compliance.

The main source of issues which caused failure to achieve A compliance level was the use of colour of three pages, the android application also had missing labels.

When checked for AA compliance both platforms failed on, multiple ways to search and contrast minimum, the failure on contrast minimum will be analysed further in section 4.3.2. Other issues which also contributed to lack of AA compliance across both platforms was the applications failure to work when text was resized to 200%.

The results of the WCAG 2.0 audit shows that the RealTime application has not reached the acceptable standard of AA compliance.

Overall, with a few minor adjustments as discussed above, the mobile website should be able to achieve AA compliance by September 2018.

4.3 Screen Reader Verification

The findings of the screen reader verification testing phase of the research which was conducted on the applications are presented and analysed below.

4.3.1 RevApp Screen Reader Testing.

The results of testing the RevApp using Talkback on an android device and VoiceOver on an apple device are displayed below.

	RevApp Pages						
	my Account	What is my Account	ROS	Home	Receipts tracker	My Enquiries	Calculators and tools
TalkBack Screen Reader Testing	PASS	FAIL	FAIL	PASS	PASS	FAIL	PASS
VoiceOver Screen Reader Testing	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

FIGURE 4.9: RevApp Screen Reader Results

The RevApp TalkBack testing failed on three pages due to the broken structure of the sentences. Sentences in paragraphs were often broken up and very difficult to follow using the Screen Reader.

The VoiceOver testing failed as it was not clear on any of the pages when it was necessary to click to proceed. The screen reader read links as headers and therefore didn't say what to do. This would cause major difficulties for a person with blindness.

4.3.2 Department of Agriculture, Food and the Marine Screen Reader Testing

The results of testing DAFM mobile website using Talkback on an android device and VoiceOver on an apple device are displayed below.

	DAFM Mobile Website										
Success Criterion	**Home**	**Latest News**	**Contact**	**About Us**	**Schemes**	**Farming Sector Info**	**Animal Health and Welfare**	**Pet Travel**	**Fisheries**	**Forestry**	**Cookie Usage**
TalkBack Screen Reader Testing	PASS	PASS	FAIL	PASS	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL
VoiceOver Screen Reader Testing	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS

FIGURE 4.10: DAFM Screen Reader Results

The Talkback screen reading testing failed on multiple pages due to missing link information, so the user would not know the destination of the link if clicked.

The VoiceOver testing was successful on all pages.

4.3.3 TravelWise Screen Reader Testing

The results of testing the RevApp using Talkback on an android device and VoiceOver on an apple device are displayed below.

	Travel Wise App				
	Alert Me	**Topical**	**Countries**	**My Trip**	**More**
TalkBack Screen Reader Testing	PASS	PASS	PASS	PASS	PASS
VoiceOver Screen Reader Testing	PASS	PASS	PASS	PASS	PASS

FIGURE 4.11: TravelWise Screen Reader Results

Both the TalkBack and VoiceOver screen reader testing was successful across the application.

4.3.4 Discovery Trails Screen Reader Testing

Unable to complete screen reader testing of the Discovery Trails app on either the android or Apple device due to basic usability issues discovered during the testing phase and explained in section 4.2.4.

4.3.5 Real Time App Screen Reader Testing

The results of testing the RealTime App using Talkback on an android device and VoiceOver on an apple device are displayed below.

	Real Time App							
	Nearby/ Search	Favourites	Bus Reminders	Route Maps	Travel Updates	Help	Feedback	Settings
TalkBack Screen Reader Testing	FAIL	PASS	FAIL	PASS	PASS	PASS	FAIL	PASS
VoiceOver Screen Reader Testing	PASS	FAIL	PASS	PASS	PASS	PASS	PASS	PASS

FIGURE 4.12: RealTime Screen Reader Results

The Talkback screen reader testing failed due to buttons and links not being labelled so the user would not know how to proceed.

The VoiceOver testing failed on one-page due to buttons not being labelled.

4.4 Colour Contrast Checker Results

The WCAG 2.0 guidelines recommend that and images of text have a contrast ratio of at least 4.5:1, the applications chosen in the research were assessed to see if they achieve this recommendation.

4.3.1 RevApp Colour Contrast Checker

The results of colour contrast testing the pages on the RevApp are displayed below.

	RevApp						
Level AA	**my Account**	**What is my Account**	**ROS**	**Home**	**Receipts tracker**	**My Enquiries**	**Calculators and tools**
Colour Contrast Check	FAIL	PASS	FAIL	FAIL	PASS	PASS	PASS

FIGURE 4.13: RevApp Contrast Checker Results

The myAccount page on the applications failed due to text which was a light Grey #BCBCBC on white #FFFFFF background with a contrast ratio of 1.9:1.

The ROS and Home pages failed due a links which had blue #0E74BD text on grey #ECEDEE background with a contrast ratio of 4.2:1.

4.3.2 Department of Agriculture, Food and the Marine Colour Contrast Checker

The results of testing DAFM mobile website using Talkback on an android device and VoiceOver on an apple device are displayed below.

	Agriculture Mobile Site										
Level AA	**Home**	**Latest News**	**Contact**	**About Us**	**Schemes**	**Farming Sector Info**	**Animal Health and Welfare**	**Pet Travel**	**Fisheries**	**Forestry**	**Cookie Usage**
Colour Contrast Check	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL	FAIL

FIGURE 4.14: DAFM Contrast Checker Results

All pages failed due to the consistent use of links with Light Grey #EBEBEB text against blue/Green #0F8799 background, this combination of colours only has a contrast ratio of 3.6:1.

4.3.3 TravelWise Colour Contrast Checker

The results of colour contrast testing the TravelWise app are displayed below.

	TravelWise				
Level AA	Alert Me	Topical	Countries	My Trip	More
Colour Contrast Check	FAIL	FAIL	FAIL	FAIL	FAIL

FIGURE 4.15: TravelWise Contrast Checker Results

The application failed the AA compliance of a contrast of at least 4.5:1 between foreground and background on all pages. This was due to consistent use of white text #FFFFFF against a green #7FB73C background, across all pages, which only had a contrast ratio of 2.4:1.

Other elements which also failed the WCAG 2.0 compliance were the use of buttons with white test #FFFFFF against a blue #00A6E0 background, contrast ratio 2.8:1, on the MyTrip and Alert Me pages.

Also, paragraph text on the Topical page fails as the grey text #797979 against a white #FFFFFF background, has a contrast ratio of 4.4:1 which is just below the AA compliance standard of 4.5:1.

4.3.4 Discovery Trails Colour Contrast Checker

Unable to complete the colour contrast checker of the Discovery Trails app on either the android or Apple device due to basic usability issues discovered during the testing phase.

4.3.5 Real Time App Colour Contrast Checker

The results of colour contrast testing the pages on the RealTime App are displayed below.

	Real Time							
Level AA	Nearby/ Search	Favourites	Bus Reminders	Route Maps	Travel Updates	Help	Feedback	Settings
Colour Contrast Check	FAIL	FAIL	PASS	PASS	FAIL	PASS	PASS	PASS

FIGURE 4.16: RealTime Contrast Checker Results

The Nearby/Search page failed as the ‘Search Details’ edit box had grey #939398 text against white #FFFFFF background with a contrast ratio of 3.1:1.

The favourites page failed as the stop information had grey #A5B8C6 text against white #FFFFFF background with a ratio of 2.0:1.

The Travel Updates failed due to green #3EBC7B text against a white #FFFFFF background which had a ratio of 2.4:1.

5. Conclusions and Future Work

5.1 Introduction

This chapter discusses the conclusions and future work from the findings and analysis chapter. The goal of this research was to answer the research questions of: 1. Do Irish Government Mobile applications comply with the WCAG 2.0 guidelines? 2. Are these mobile applications compliant with the EU Web Accessibility Directive? 3. How can the WCAG 2.0 guidelines be improved regarding mobile accessibility?

This research was conducted using available literature and an accessibility audit of a sample of five Irish eGovernment mobile applications on both Android and iOS platforms. The chosen mobile applications were evaluated against the current WCAG 2.0 guidelines, screen reader evaluations using the platforms inbuilt systems, along with a colour contrast checks were also conducted.

5.2 Conclusion

None of the five mobile applications tested reached the WCAG 2.0 AA compliance level that the Government have committed to achieve on all eGovernment websites and applications. In fact, none of the applications that could be tested passed the A compliance level, meaning accessing these applications could prove problematic to people with disabilities and will not be compliant with the EU directive in September 2018.

Overall, the applications appeared to be developed with accessibility in mind as images, audio, video, time dependent processes etc are kept to a minimum or not present on the applications at all. This suggests that the development teams are considerate of the accessibility and are developing applications that are usable and accessible to a wide range of people. They appear to be following the National Disability Authorities guidelines regarding universal design for ICT.

The research indicates that the main issue preventing these applications in achieving AA compliance can easily be captured, reported and fixed during the testing phase of the software development lifecycle. The applications all functioned corrected indicating that functional testing had taken place but the issues discovered around the colour contrast and screen readers indicate that accessibility testing may not have been conducted.

All the tested applications had issues with colour contrast selection, failing on the AA compliance level of 4.5:1. This issue can be easily fixed but equally should have been

discovered during the accessibility testing of the applications. Contrast checker testing is easy to conduct as there are many tools on both platforms to assist in this task.

Also, three out of four of the applications tested also had issues with the inbuilt screen readers on the android and iOS platforms, this suggests a lack of accessibility testing before the applications are released or perhaps a lack of accessibility expertise within the development teams.

Screen reader testing is more complex and requires some expertise. Ideally, screen reader testing should include a screen curtain to ensure the user can identify what to do next based only on the screen reader dialogue.

In keeping with the principle of universal design, applications should be designed to be inclusive for all. Part of this process needs to include non-functional testing including usability and accessibility. The emphasis on accessibility testing will become more important as the September 2018 deadline approaches, as Departments and Public bodies could face legal consequences if found not to be compliant.

To assist in achieving compliance with the European Web Accessibility, accessibility testing should be mandatory across all Government departments and public bodies websites and mobile applications as it will help in compliance with the WCAG 2.0 guidelines. The office of the Government CIO should introduce mandatory guidelines and testing techniques to all development teams to give guidance and practical advice on how to achieve the AA compliance level needed from September 2018.

As the research was conducted on five random mobile applications it can be deduced that mobile applications produced by Government departments and public bodies will not be compliant with the upcoming EU Web Accessibility directive in their current state.

The research shows how accessibility testing needs several different techniques and approaches and no one method can assure compliance. The testing framework applied during this research proved to be valuable in catching various accessibility problems.

Mobile application development is costly to produce and maintain, making accessibility a requirement adds to the complexity involved in the development life cycle. The British Government have decided to abandon mobile application development, due to some of these issues, in favour of mobile responsive websites, “For government services, we believe the benefits of developing and maintaining apps will very rarely justify their costs, especially if the underlying service design is sub-optimal. Departments should focus on improving the quality of the core web service.” (Loosemore, T. 2013).

Even though, this research solely focused on accessibility, the findings from this research, would strengthen the approach taken by the British Government as fixing the accessibility issues discovered and achieving WCAG AA compliance will involve releases onto two platforms instead of one, double the development time, double the testing time and double the cost.

The current WCAG 2.0 guidelines need some modification to be applicable to mobile applications. The research found the following success criteria need to be modified or removed when considering the accessibility of mobile applications.

Success Criteria 2.1.1 (Level A compliance) – Keyboard. This success criteria states that all content and functions must be accessible via a keyboard. As mobile applications are built for touch screens, this criterion could be modified to state that all content and functions must be accessible via keyboard or keyboard equivalents. This is more generic and independent of the technology and platforms used.

Success Criteria 2.1.2 (Level A compliance)- No Keyboard Trap. This success criteria states that users must be able to exit out of windows, pop ups, dialogue boxes, etc via the keyboard. Again, as mobile applications are for touch screens, this criterion should be modified to state, 'No Traps'. By removing the emphasis on 'Keyboard' this criterion is now more generic and can be applied to mobile applications.

Success Criteria 2.4.5 (Level AA compliance) – Multiple Ways. All the mobile applications tested failed on this criterion, as it expects more than one way to access a webpage. As mobile applications are not generally built to display masses of information and tend not to replace a main website of an organisation or business, this criterion of 'multiple ways' may need to be modified to reflect the purpose of mobile applications. A simpler success criterion stating that a 'Home' button must always be present might be more applicable to mobile applications and make navigation of mobile applications easier.

Success Criteria 2.1.3 (Level AAA compliance) – Keyboard (No Exception). This criterion states that all content must be operable from a keyboard, with no exceptions. It would be cost prohibitive and inconsistent to have development teams implement keyboard handling on mobile applications. This criterion should be modified to state 'Keyboard or Keyboard equivalents'.

5.2.1 Limitations of this Research

The testing of the five mobile applications was done during August/September 2017 and the conclusions are based on these findings during this period. As mobile applications, like all technology, are being updated regularly the current findings may not be valid or be repeated in similar research.

The sample mobile applications were not tested on the latest versions of Android or iOS and this may impact the accessibility of the applications. Apple released iOS 11 during the research and this may improve accessibility of the applications.

5.2.2 Interesting Aspects of the Research

An interesting aspect discovered during the research was the differences between the Android and iOS platforms. This was particularly evident when screen reader testing the RevApp. On the iOS platform, a person reliant on the screen reader would not know how to proceed on any of the pages, making the App inaccessible. This further highlights the need for screen reader testing across all platforms that the applications will be used on.

Another interesting aspect was the out dated or lack of accessibility statements on some of the chosen Departments or Public Bodies websites. The NDA provide an accessibility statement toolkit which is freely available to all so all Departments and Public bodies should have their accessibility statements current and easily found.

5.3 Future Work in This Area

- A similar accessibility audit should be conducted on the same mobile applications post the September 2018 deadline to evaluate if the legal requirement has the required effect of making all eGovernment applications accessible to all. The results of this research would be a great interest to disability groups and may be useful in any lobbying of Government. Also, the results may be useful to the government Departments themselves as it could give them insight into any accessibility issues that may exist on their applications.

- An accessibility audit should be conducted on the chosen Departments main webpages to discover if the issue with accessibility is confided to their mobile applications or perhaps a problem within their development teams regarding developing for accessibility. Such research should include interviews with the chosen development teams to determine if their understanding of developing for accessibility results in applications which pass the WCAG 2.0 guidelines. Such research may uncover the need for a dramatic culture change within the development teams so that accessibility becomes a priority.

- The research found that the mobile application accessibility testing tool market is not yet mature and there is a gap in the market for a tool for both an android and iOS platforms or a tool which can work across both platforms. As stated before, automated tools cannot replace human testing but a tool can highlight accessibility issues and replace some of the manual testing needed now.

- As accessibility will be a legal requirement from September 2018, the current situation of self-certification has proved not to be reliant enough and some independent check, possibly by the National Disability Authority, may be necessary before publication of websites and mobile applications to ensure compliance with the legislation.

- Future research should consider the visibility of the use of open API’s in the e-government and m-Government sector. This approach is being developed in the English banking sector following the EU's new Payment Services Directive

(PSD2). This could take the responsibility of developing applications away from government development teams to the private sector. Hence, the accessibility requirement will fall on these third-party developers.

6. References

Android (2017) *Accessibility* Retrieved from: https://developer.android.com/guide/topics/ui/accessibility/index.html on 1st April 2017.

Android (2017) *The Android Story* Retrieved from: https://www.android.com/history/#/marshmallow on 1st June 2017

Apple (2017) *Accessibility on iOS* Retrieved from: https://developer.apple.com/accessibility/ios/ on 1st April 2017.

Apple (2017) *Accessibility.* Retrieved from: https://www.apple.com/lae/accessibility/ on 1st April 2017.

Babbie E. (2010) *The Practice of Social Research*. 12th edn. Belmont, CA.

Basdekis I, Klironomos I, Metaxas I and Stephanidis C (2010) An overview of web accessibility in Greece: a comparative study 2004–2008. Universal Access in the Information Society, **Volume 9**, (Issue 2), Pages: 185-190

Bergvall-Kareborn, B and Howcroft D (2014) Persistent problems and practices in information systems development: a study of mobile applications development and distribution. *Information System Journal,* **Volume 24**, (Issue 5), Pages 425–444

Black, I. (2006). The presentation of interpretivist research. *Qualitative Market Research: An International Journal*, 9(4), 319–324.

Blee, Kathleen (2013). *Interviewing Activists in David Snow, Donatella della Porta, Bert Klandermans, and Doug McAdam (eds),* Blackwell Encyclopedia of Social Movements. Oxford, Blackwell, pp. 603–6.

Bouck, E (2017) *Assistive Technology* Sage Publication, Los Angeles

Brians, Craig Leonard et al. (2011) *Empirical Political Analysis: Quantitative and Qualitative Research Methods*. 8th edn. Longman, Boston.

Carson, D., Gilmore, A., Perry, C., and Gronhaug, K. (2001). *Qualitative Marketing Research*. Sage Publishing, London

Coelho Serra L, Pedroso Carvalho L, Pereira Ferreira L, Belimar Silva Vaz J and Pimenta Frieir A (2015) Accessibility Evaluation of E-Government Mobile Applications in Brazil. *Procedia Computer Science,* **Volume 67,** Pages: 348-357

Cunningham,M. Dempsey, A. Marcaigh, F. Philips, S. and Quirk, D (2012) *The Lived Experience of People in Ireland using Online Public Services*. Dublin: Amas Ltd.

Citizens Information (2016) *European Laws* Retrieved from: http://www.citizensinformation.ie/en/government_in_ireland/european_government/eu_law/european_laws.html on 17th March 2017.

Csapó A, Wersényi G, Nagy H and Stockman T (2015*)* A survey of assistive technologies and applications for blind users on mobile platforms: a review and foundation for research*. Journal on Multimodal User Interfaces*, **Volume 9**, (Issue 4), pp 275–286

CSO (2011) *Census 2011 Profile 8 Our Bill of Health - Health, Disability and Carers in Ireland* Retrieved from: http://www.cso.ie/en/census/census2011reports/census2011profile8ourbillofhealth-healthdisabilityandcarersinireland/ on 1st March 2017

CSO (2013) *Women and Men in Ireland 2013* Retrieved from: http://www.cso.ie/en/releasesandpublications/ep/p-wamii/womenandmeninireland2013/healthlist/health/ on 1st March 2017

CSO (2016) *Information Society Statistics – Households 2016* Retrieved from: http://www.cso.ie/en/releasesandpublications/er/isshh/informationsocietystatistics-households2016/ on 2nd March 2017.

DAFM (2016) *About Us* Retrieved from: https://www.agriculture.gov.ie/aboutus/ on 1st May 2017.

DAFM (2017) *Web Accessibility Statement.* Retrieved from: https://www.agriculture.gov.ie/accessibility/ on 1st May 2017.

Denzin N, Lincoln Y (2005) *The SAGE Handbook of Qualitative Research.*3rd edn. Sage Publishing, London.

DFA (2013) *Our Role and Policies.* Retrieved from: http://www.dfa.ie/our-role-policies/ on 3rd May 2017

DPER (2014) *Civil Service Renewal Plan* Government Buildings: Dublin

Diaz-Bossini J and Moreno L (2014) Accessibility to Mobile Interfaces for Older People. *Procedia Computer Science,* **Volume 27,** Pages: 57-66

Duigan, J. (2016) *A Dictionary of Business Research Methods*. Oxford University Press: London

Europa (2010) *European Disability Strategy 2010-2020: A Renewed Commitment to a Barrier-Free Europe* Retrieved from: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0636:FIN:en:PDF on 17th March 2017.

Europa (2017) *European Accessibility Act* Retrieved from: http://ec.europa.eu/social/main.jsp?catId=1202 on 17th March 2017.

FailteIreland (2017) *Accessibility*. Retrieved from: http://www.failteireland.ie/Footer/Accessibility.aspx on 3rd June 2017

FailteIreland (2017) *Failte Ireland.* Retrieved from: http://www.failteireland.ie/ on 3rd June 2017.

Galliers R (1991) Choosing Appropriate Information Systems Research Approaches: A Revised Taxonomy. *In Proceedings of the IFIP TC8 WG8.2.* Pages 317—335.

Gartner (2016) *Gartner Says Five of Top 10 Worldwide Mobile Phone Vendors Increased Sales in Second Quarter of 2016*. Retrieved from: http://www.gartner.com/newsroom/id/3415117 on 1st May 2017.

Gordon, T (2002) *E-Government – Introduction.* ERCIM News No.48

Gov.ie (2013) *DAFM mobile website.* Retrieved from: http://e.gov.ie/reporting/results/?action=9 on 1st May 2017.

Government of Ireland (2005) *Disability Act* Stationery Office: Dublin

Government of Ireland (2015) *Equal Status Acts 2000-2015* Stationery Office: Dublin

Gray D (2009) *Doing Research in the Real World.* 2nd edn. Sage Publishing, London.

Herman,I (2006) *Why Web Standard are Important: An overview of W3C, its operation and current technical directions* W3C

Hirschheim A (1985) *Information Systems Research Methodology: An Introduction to the Debate. Research Methods in Information Systems*. Elisiver Science Publishers, Amsterdam.

Hogan J, Dolan P, Donnelly P (2009) *Introduction: Approaches to Qualitative Research* Theory and Its Practical Application. Pages 1-18. Oak Tree Press, Cork.

Hung, S. Chang, C and Kuo, S. (2013) User acceptance of mobile e-Government services: An Empirical Study. *Government Information Quarterly* **Vol 30** (1) pp: 33-44

ISO (2013) *Usability of consumer products and products for public use* Retrieved from: https://www.iso.org/obp/ui/#iso:std:iso:ts:20282:-2:ed-2:v1:en on 2nd March 2017.

Langdon P, Clarkson P and Robinson P (2008) *Designing Inclusive Futures.* Springer-Verlag, London.

Laurin S, Cederbom A, Martinez-Usero J, Kubitschke L, Wynne R, and Cullen K (2014) *Measures to Improve Accessibility of Public Websites in Europe.* National Disability Authority, Dublin

Levin, D. M. (1988). *The opening of vision: Nihilism and the postmodern situation*. Routledge, London.

Loosemore T (2013) *We're not 'appy. Not 'appy at all.* Retrieved from: https://gds.blog.gov.uk/2013/03/12/were-not-appy-not-appy-at-all/ on 1st September 2017.

Miller, C (2017) *Tim Cook calls accessibility a 'core value of Apple' as he sits down for trio of interviews in honor of GAAD.* Retrieved from: https://9to5mac.com/2017/05/17/tim-cook-calls-accessibility-a-core-value-of-apple-as-he-sits-down-for-trio-of-interviews-in-honor-of-gaad/ on 1st June 2017.

Morgan G (1983) Social science and accounting research: A commentary on Tomkins and Groves. *Accounting, Organizations and Society*. **Volume 8,** (Issue 4), Pages 385-388.

Mulvey, C (2008) *Web Accessibility of eGovernment Websites.* Unpublished Masters Thesis Dublin Institute of Technology, Dublin.

National Transport Authority (2017) *About the Authority.* Retrieved from: https://www.nationaltransport.ie/about-us/ on 3rd June 2017.

National Disability Authority (2015) *Universal Design Guidance for Online Public Services* Retrieved from: http://universaldesign.ie/Web-Content-/Guidance-for-Online-Public-Services-1.pdf on 17th March 2017.

NDA (2017) *Definitions* Retrieved from: http://nda.ie/Disability-overview/Definitions/ on 2nd March 2017

Neilsen, J (2012) *How Many Test Users in a Usability Study?* Retrieved from: https://www.nngroup.com/articles/how-many-test-users/ on 5th July 2017.

Neuman, L. W. (2000). *Social Research Methods: Qualitative and Quantitative Approaches.* 4th edn, Allyn and Bacon, USA.

Ontario (2015) *Accessibility for Ontarians with Disabilities Act, 2005* Retrieved from: https://www.ontario.ca/laws/statute/05a11 on 21st March 2017.

Red Cardinal (2006) *eGovernment Accessibility Analysis.* Retrieved from: http://www.redcardinal.ie/webdev/10-12-2006/irish-egovernment-accessibility-analysis on 15th February 2017.

Revenue (2017) *Revenue's Accessibility Statements*. Retrieved from: http://www.revenue.ie/en/online-services/support/technical-requirements/accessibility-statement/index.aspx on 3rd May 2017.

Rubin H and Rubin I (2005) *Qualitative Interviewing: The Art of Hearing Data.* 2nd edn. Sage Publishing, London.

Saunders, M., Lewis, P., Thornhill, A. (2012) *Research Methods For Business Students*, 6th edn. Pearson, London.

Saunders, M., Lewis, P., Thornhill, A. (2009) *Research Methods For Business Students*. 5th edn. Pearson, London.

Saunders, M., Lewis, P., Thornhill, A. (2003) *Research Methods For Business Students*. 3rd edn. Prentice Hall, London.

Shelley G and Vermaat M (2008) *Discovering Computers: Fundamentals.* 5th edn, Course Technology, Boston

Stephanidis, C (2011) *Universal Access in Human-Computer Interaction. Design for All and eInclusion* Part 1. Springer, New York

TotalValidator (2017) *Introduction*. Retrieved from: https://www.totalvalidator.com/ on 5th July 2017.

Transport for Ireland (2017) *Accessibility.* Retrieved from: https://www.transportforireland.ie/accessibility/ on 3rd June 2017.

Trulock, V. (2006) *A Comparative Investigation of the Accessibility Levels of Irish Websites.* Edinburgh: Napier University.

WebAim (2015) *Screen Reader User Survey #6.* Results Retrieved from: https://webaim.org/projects/screenreadersurvey6/ on 23rd March 2017.

WebAim (2017) *WAVE web accessibility tool.* Retrieved from: http://wave.webaim.org/ on 1st July 2017.

Weckler, A (2015) Irish mobile phone usage highest in the western world, global stats reveal**.** *Irish Independent* 27th August 2015.

Wentz B, Pham J, Tressler K (2017) Exploring the accessibility of banking and finance systems for blind users. *First Monday,* **Volume 22,** Pages: 3-6

Wilson, J. (2010) *Essentials of Business Research: A Guide to Doing Your Research Project*. Sage Publishing, London.

World Health Organisation (2015) *WHO Global Disability Action Plan 2014-2021.* WHO Press, Switzerland.

W3C (2017) *Web Accessibility Evaluation Tools List*. Retrieved from: https://www.w3.org/WAI/ER/tools/ on 1st June 2017.

W3C (2008) *Web Content Accessibility Guidelines (WCAG) 2.0* Retrieved from: https://www.w3.org/TR/WCAG20/ on 1st March 2017.

xTechTarget (2013) *Mobile App.* Retrieved from:http://whatis.techtarget.com/definition/mobile-app on 3rd April 2017.

7. Appendices

Appendix 1: WCAG 2.0 Checklist

WCAG 2.0 checklist Level A (Beginner)

Guideline	Summary
1.1.1 – Non-text Content	Provide text alternatives for non-text content
1.2.1 – Audio-only and Video-only (Pre-recorded)	Provide an alternative to video-only and audio-only content
1.2.2 – Captions (Pre-recorded)	Provide captions for videos with audio
1.2.3 – Audio Description or Media Alternative (Pre-recorded)	Video with audio has a second alternative
1.3.1 – Info and Relationships	Logical structure
1.3.2 – Meaningful Sequence	Present content in a meaningful order
1.3.3 – Sensory Characteristics	Use more than one sense for instructions
1.4.1 – Use of Colour	Don’t use presentation that relies solely on colour
1.4.2 – Audio Control	Don’t play audio automatically
2.1.1 – Keyboard	Accessible by keyboard only
2.1.2 – No Keyboard Trap	Don’t trap keyboard users

2.2.1 – Timing Adjustable	Time limits have user controls
2.2.2 – Pause, Stop, Hide	Provide user controls for moving content
2.3.1 – Three Flashes or Below	No content flashes more than three times per second
2.4.1 – Bypass Blocks	Provide a 'Skip to Content' link
2.4.2 – Page Titled	Use helpful and clear page titles
2.4.3 – Focus Order	Logical order
2.4.4 – Link Purpose (In Context)	Every link's purpose is clear from its context
3.1.1 – Language of Page	Page has a language assigned
3.2.1 – On Focus	Elements do not change when they receive focus
3.2.2 – On Input	Elements do not change when they receive input
3.3.1 – Error Identification	Clearly identify input errors
3.3.2 – Labels or Instructions	Label elements and give instructions
4.1.1 – Parsing	No major code errors
4.1.2 – Name, Role, Value	Build all elements for accessibility

WCAG 2.0 checklist Level AA (Intermediate)

Guideline	Summary
1.2.4 – Captions (Live)	Live videos have captions
1.2.5 – Audio Description (Pre-recorded)	Users have access to audio description for video content
1.4.3 – Contrast (Minimum)	Contrast ratio between text and background is at least 4.5:1
1.4.4 – Resize Text	Text can be resized to 200% without loss of content or function
1.4.5 – Images of Text	Don't use images of text
2.4.5 – Multiple Ways	Offer several ways to find pages
2.4.6 – Headings and Labels	Use clear headings and labels
2.4.7 – Focus Visible	Ensure keyboard focus is visible and clear
3.1.2 – Language of Parts	Tell users when the language on a page changes
3.2.3 – Consistent Navigation	Use menus consistently
3.2.4 – Consistent Identification	Use icons and buttons consistently
3.3.3 – Error Suggestion	Suggest fixes when users make errors
3.3.4- Error Prevention (Legal, Financial, Data)	Reduce the risk of input errors for sensitive data

WCAG 2.0 checklist Level AAA (Advanced)

Guideline	Summary
1.2.6 – Sign Language (Pre-recorded)	Provide sign language translations for videos
1.2.7 – Extended Audio description (Pre-recorded)	Provide extended audio description for videos
1.2.8 – Media Alternative (Pre-recorded)	Provide a text alternative to videos
1.2.9 – Audio Only (Live)	Provide alternatives for live audio
1.4.6 – Contrast (Enhanced)	Contrast ratio between text and background is at least 7:1
1.4.7 – Low or No Background Audio	Audio is clear for listeners to hear
1.4.8 – Visual Presentation	Offer users a range of presentation options
1.4.9 – Images of Text (No Exception)	Don’t use images of text
2.1.3 – Keyboard (No Exception)	Accessible by keyboard only, without exception
2.2.3 – No Timing	No time limits
2.2.4 – Interruptions	Don’t interrupt users

2.2.5 – Re-authenticating	Save user data when re-authenticating
2.3.2 – Three Flashes	No content flashes more than three times per second
2.4.8 – Location	Let users know where they are
2.4.9 – Link Purpose (Link Only)	Every link's purpose is clear from its text
2.4.10 – Section Headings	Break up content with headings
3.1.3 – Unusual words	Explain any strange words
3.1.4 – Abbreviations	Explain any abbreviations
3.1.5 – Reading Level	Users with nine years of school can read your content
3.1.6 – Pronunciation	Explain any words that are hard to pronounce
3.2.5 – Change on Request	Don't change elements on your website until users ask
3.3.5 – Help	Provide detailed help and instructions
3.3.6 – Error Prevention (All)	Reduce the risk of all input errors