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**Universal design of airline applications**

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## Preface

I have a background of Software engineering in my Bachelors where I have studied all the steps included in the Software Development Life Cycle (SDLC). I have a strong passion towards software development with which I work hard and try to achieve more in it.

The reason of my topic of thesis “Universal design of airline applications” is due to two reasons, first of all is that it has to relate to universal design and secondly I myself am a small fan of aviation and I love air travel, so I adjusted my interest in my Master’s programme and have chosen this topic.

The target group of this thesis are all the respected examiners and then also mainly the researchers who want to work further in the future related to this domain, the developers and the designers who will create these kinds of applications and all the business stakeholders who are the owners of airlines.

I would like to thank my Supervisor Mr. Terje Gjørseter at OsloMet. He has been a great help for me and guided me all from the beginning till the end and helped me with each and every thing with all my questions and contributed a lot in the ideas that how we should do the things, checking my writing in each phase of my thesis.

At the end I would like to thank the institution which has helped me alot to reach this point and get me through my last two phases and given me the chance to complete my thesis.

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## **Abstract**

Air travel industry is one of the biggest industries in the world. The world is moving more and more towards electronic operations rather than physical approaches, which means the trend of e-commerce and more online bookings. We need to give importance to all kinds of digital users including the disabled persons. We decided to analyze some airline applications and find accessibility and usability issues from it and suggest some guidelines along with a prototype which can help the online booking users to do their bookings much faster which can help this industry to grow more.

Three popular airline mobile applications were analyzed for their accessibility and usability during the ticket booking process using four methods including user testing through google forms, manual accessibility testing, automated accessibility testing and expert usability testing using Nielsen Norman's ten heuristics. The three apps analyzed are: Norwegian, SAS (Scandinavian Airlines) and KLM (Royal Dutch Airlines – in English). Two of the airlines Norwegian and SAS are most popular in Norway at least and the KLM being one of the most popular in the world. Impressed by at least one application but still issues were found during accessibility and usability testings, but also more interesting facts during user testing which gave us diverse results. It was clearly found that there are still basic areas which need to get improved such as contrast, size of items, information etc. As a result of this we produced set of guidelines and a prototype showing some steps to follow those guidelines.

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# 1. Introduction

We can see an increasing trend of air travel clearly these days. These days most people wish to travel by air, due to their hobby, spending vacations or for business. ICT has a positive impact on travel (Zhang et al., 2007). Online bookings have increased now and there are stakeholders like travel agencies and tourism marketing managers for whom it is important to know how customers are behaving (Mouakket & Al-hawari, 2012). There are a lot of questions related to accessibility and usability these days around the ICT users and experts both. Universal design is getting the popularity slowly and eventually it seems that it will be taken as seriously as it should be as Universal design is not only important for people with disabilities but it is important for every kind of users because it makes things simple, easy to use and understandable and thus less time being consumed in achieving the goal. E-commerce has power to reach customers globally and due to which social science and business science focuses on cross-national and cross-cultural Internet marketing (Al-Maghrabi et al., 2011).

Talking about the number of users who can benefit from online services these days we must include the findings by Coppel (2000) according to which there were only 3 million internet users in 1991. Roser et al. (2015) says that today there are 3.5 billion online users. We can imagine how important it would be to have universal design in the ICT world. Let's take our discussion towards mobile phones in particular towards smartphones. As the world of ICT is progressing, smartphones are getting more power and allowing users to access the internet and a lot of services (Mohd Suki & Mohd Suki, 2017). In the blog of Khalaf & Kesiraju (2017), it is found that an average US consumer spends five hours in a day on his/her mobile devices which also showed that the consumers use less browser on their phones as compared to other applications. According to Ross et al. (2017) mobile apps are the ways due to which people are improving their lives in aspects such as personal finances, communication, community engagement, and transportation. Many important services like government, education, health and travel are going towards being digital (Vavik, 2009). Jamal and Habib (2020) also mentioned in the study that smartphones are impacting travel and its outcomes. Talking about general public

transport, one of the studies by Kroesen and Handy (2015) showed that technology is generating more out of home activities which has impacted among the young adults more public transport in general. Airline companies are making benefits from this and enhancing their websites and also providing the mobile versions of it (Mohd Suki & Mohd Suki, 2017). Ballantyne et al. (2018) states that it is very important for mobile devices and the applications running on them to be accessible due to the increasing number of their usage.

If seen from marketing's point of view then the greatest advantage of mobile application is that service providers can directly reach their customers whenever and wherever from and to (Lubbe & Louw, 2010). Sang Hiun Kim (2006) mentions that m-commerce is something which is benefiting the e-commerce companies further. E-commerce is beneficial over physical shopping as the consumers have more control and access to multiple retailers and thus have price control (Hussain et al., 2017).

Talking about mobile applications in this study and particularly the airlines applications, for any mobile application, aesthetics might be more important for some people but accessibility and usability of the application is more important than aesthetics for some. However, It is worth mentioning here that Linghammar (2007) noted in his study that aesthetically good interfaces were perceived as more usable. Meola (2016) in business Insider report states that according to Criteo report mobile booking for air travel was 26% world wide in the first quarter of 2016 in which most of them happened at the last minute and 60 % of all bookings through online travel agency was booked from mobile phones with the addition of 7% on tablets. Age groups from 16-34 use their smartphones more to plan their trips compared to other age groups (Jamal & Habib, 2020).

Siebra et al. (2015) found that according to WHO, 15 % of the population have some kind of impairment and several governments know this issue and they have created laws relating to Universal design in ICT (Information and Communication Technology).

The main purpose of this paper is to analyze the different airlines applications with respect to universal design as most of the people use their mobile/tablets to do most

of their daily routines because it's easier to carry small devices . Air travel is getting more and more common now and it is getting cheaper. For example, Most North Americans (99%) took at least one leisure trip in 2017 (Gelfeld, 2017) .In the context of intense market competition, airlines are enriching their business operations by offering flight ticket booking apps that can be downloaded on mobile devices (Mohd Suki & Mohd Suki, 2017).

Many people use mobile phones as the primary means of communicating and deciding and searching on their daily life routine things. Travelling nowadays is getting very affordable and people want to spend time in other countries for different purposes. Keeping every kind of person in our minds we must invest our time to make the design usable, accessible and in short universal.

Mobile applications are supposed to be accessible for every still many of the most popular ones are not as claimed by El-Glaly et al. (2018) and it is noted by Gündüz and Pathan (2012) that poor choices of the usability requirements in the development phase are the cause of under utilization of smart phones facility. Talking about flight applications Gündüz & Pathan (2012) noted that a number of applications in the market provide flight search and booking but mostly they show that they were designed without the user's context and preferences. Our purpose in this study is to suggest some design criteria for airline applications which they should use and build their applications according to and facilitate almost every kind of person and at the end we will provide a high fidelity prototype which will demonstrate these guidelines. We will be focusing on the overall aspect of universal design with mostly covering accessibility and usability. We will try to find the common problems with the mobile platforms in space of their accessibility and usability and design as a whole and will try to fill the gaps.

## **1.1 Research Question**

Based on the problem statement above, we define the following research question.



*How can the airline booking applications be made better with respect to universal design so that they can be more usable to every kind of person?*

Some specific airline applications will be analyzed and barriers will be detected from them related to usability and accessibility due to which people might be reluctant to use this service on their phones. We will be using WCAG(Web Content Accessibility guidelines) version 2.1 provided by W3C as the standard guidelines for WEB and the new guidelines derived from the same guidelines specifically for mobile accessibility. We will also be using Universal design principles provided by North Carolina State University(NCSU) (*The 7 Principles | Centre for Excellence in Universal Design*, n.d.). At the end we plan to implement a high fidelity prototype which will be a practical example of the methods to get around typical barriers that we have detected. We might take help from travel companies websites to access how well they have their web existences as compared to mobile versions. Small Improvements can make the design usable and less complex which puts less stress on the user's mind while using.

## **2. Literature Review**

### **2.1 Complexity of domain**

Burmistrov (2009) states that mobile air ticketing is already a cognitively complex task even on desktop computers due to the large amount of list to select from such as price, dates, times etc and putting stress on mind which actually puts the need to have a mobile application for. Moreover, he noted that the mobile environment does not allow for long cognitively complex interactions.

Burmistrov (2009) recommended reducing the unnecessary information that we should reduce the size of information on the search results page and should not show a lot of information that can be shown on the summary page after the selections and decisions of the users. Burmistrov (2009) contributed a lot in the understanding of mobile applications and in particular the topic of mobile air travel booking as well.

### **2.2 Factors which influence the use of airline services and online purchase of tickets**

Mohd Suki & Mohd Suki (2017) studied the intention of individuals to use flight booking apps. According to them, advanced technologies should be used in order to brand their product and encourage people to make use of it. TAM(Technology Acceptance Model) factors like perceived usefulness, perceived ease of use, behavioural intention and actual usage and the integrated factors of perceived value, perceived trust, subjective norm, and airline image were used to study the intentions of individuals to use such air ticket booking applications. It was found by both Kim et al. (2009) and Norazah et al. (2011) related to impact of perceived usefulness and perceived ease of use on the use of e-booking based on which the it was also concluded by Mohd Suki & Mohd Suki (2017) that if the e-booking platform is both useful and easy to use, users will have a positive intention towards using e-booking. This is the main point which actually is one of the purposes of Universal design that

any ICT application should be usable and easy to use. Talking about people's intentions to use the airline apps, another factor discussed by Mohd Suki & Mohd Suki (2017) is "perceived value" which is defined by Walter et al. (2001) as "trade-off between multiple benefits and sacrifices". According to Hapsari et al. (2016) the quality of service should be increased to enhance the customer's satisfaction on airline services and perceived value and service quality is directly proportional to customer satisfaction. Perceived value can be increased in some ways as mentioned in study by Ruiz-Mafé et al. (2009) like online check-in at the same web address, providing lodging offers, boarding pass printing service, option to change flight and your seat. These were given as website usability features but can be applied to mobiles for online purchase of tickets.

Behavioural intention is defined by Ajzen (1991) as "indication of how hard people are planning to try and how much effort they are planning to exert in order to perform the behavior". Mohd Suki & Mohd Suki (2017) assumed and the results supported the assumption that people will put more efforts in achieving their goals if they have good intentions to use the system on their phone. This shows the importance of universal design.

So there are certain factors which influence the intention of usage of the e-ticketing on mobile devices. One other factor discussed by Mohd Suki & Mohd Suki (2017) is the "airline image". If airlines have a good image of their company, the next time the consumer will come back to them and it has the effect on the choice of airline to book. Which means if the airline provides good design and usefulness through their app for the first time, the customer will come back and use the app next time.

Coming back to study by Ruiz-Mafé et al. (2009) it was found that both perceived risk and perceived usefulness influence the use of online airline ticketing. And also that if the website is easy to use then there are more chances that users will purchase tickets online.

Al-Maghrabi et al. (2011) studies the factors which bring the customers to use airline websites. He revised the TAM (Technology Acceptance Model) and integrated it to Expectation confirmation theory in order to find the intention of people to use airline

websites. He found the determinants of online airline ticket booking as Perceived usefulness, enjoyment, social pressure, and loyalty incentives in Saudi Arabia. Al-Maghrabi et al. (2011) mentioned that according to ECT (Expectation Confirmation theory), the user will have an intention to repurchase if the product meets their initial expectation. This makes it clear how important for an airline company it is to have both good functionality but also usable and accessible design. Moreover, according to Al-Maghrabi et al. (2011) these expectations can increase which were not present at the first if the services are useful and made even better afterwards.

The Internet is the medium which makes it possible for the users to find the flight related information like schedules, prices and it can make it very easy to compare the prices with other options available Al-Maghrabi et al. (2011). Al-Maghrabi et al. (2011) mentioned 'Site Quality' which puts a positive impact on using airline websites. Perceived usefulness and shopping enjoyment means that a user can return (Koufaris, 2002). This can be directly related to airlines websites also.

Enjoyment makes the most difference followed by perceived usefulness and then the social media pressure from the media and based on this truth e-flight booking should be made useful and enjoyable (Al-Maghrabi et al., 2011). They have given the example of [www.nike.com](http://www.nike.com) in which users can change the shoes, colors, styles. Managers are advised by Al-Maghrabi et al. (2011) to increase the website security, content and design and also dual language features should be added in order to retain customers and also recommended one of the ways to increase enjoyment is that maybe the airline website can provide 360 degree inside view of the airplane to increase the enjoyment of the consumer while booking a ticket. One more suggestion made in this factor is the technique which Amazon uses which is "users who bought this item were interested in this item as well" and airlines websites should focus on these things before they focus on other aspects of their services (like usability and accessibility).

Al-Maghrabi et al. (2011) also noted that the perception of family and friends of customers can be made positive through the airlines websites related to website's usefulness, site quality, interactivity and enjoyment which will improve the trustworthiness of the company (resulting in more usage of service).

Talking about the importance of accessibility a participant in the study conducted by Tigwell et al. (2018) commented a very notable thing and according to him “because accessibility improves usability and user experience it would increase the likelihood of people returning to a product”. Meng et al. (2015) found factors which makes smartphone usage positive towards air travel due to positive behaviour towards using smartphones.

Leitner et al. (2009) while analyzing the user requirements of a railway ticketing systems with focus on semantic accessibility for older users have found in their study that older adults do not compare other similar services to get there problem solved, they instead perceive the problem as a general problem related to service and that these older adults want to consider the web applications as real environment and expect the feedback which makes sense so that they have all control over it. Considering older adults they also noticed that older adults do not really care about technical problems or the privacy statements if the system is consistent and useful (lets them do what he/she wants to).

## **2.3 Universal design of flight booking systems**

Gündüz & Pathan (2012) focused on usability problems with mobile flight booking systems of Turkish airlines mobile app and provided solutions to them with prototypes. He found that users felt very much satisfied with the easiness of the application and usability is very concerned subject to users preferring mobile flight applications instead of booking online or with agencies. They have also mentioned the fact that there is less work on the investigation of mobile user interface and usability and mobile flight applications usability also instead of few doing research but on older phones(not smartphones). It was also mentioned that web usability is considerably simple to achieve than mobile usability due to more complex challenges. Some of them are performance differences as compared to desktop PCs, memory and screen sizes (Hertzog & Torrens, 2004). He studied many usability issues on mobile and investigated the mobile flight applications usability on small-sized touch devices as compared to older studies which were on non-touch

devices and this served as the main motivation for them.

They, at the time of study, assessed the usability of Turkish airlines mobile app by using 2G. They found that generally people prefer PCs instead of mobile to book a flight even in emergency situations due to convenience. According to the survey with questionnaire they found that 75% users did not prefer to use this app to book flight (in 2012).

Some of the usability problems which we find from this study useful can be summarized here briefly as it is worth discussing. According to the study the choice of the icons used were not understandable and simple. Moreover the placement of icons wrongly used was also one of the problems. Suggested solution was that if the icon is not a link or clickable it should be on the left side of the text and on the right side if it is something to be clicked. Redundancy in the completion of steps was one more problem found in the app in the sense that if the user's internet goes down he/she has to fill all the information on all the steps again which is noted as inefficient. They provided a prototype where all the information is collected from the user in one page only after analyzing other booking apps and the guidelines from HCI(Human Computer Interaction). Naming of the options were found confusing by the participating users, as an example provided was 'mobile ticket' where some users thought it was movie ticket or concert tickets. So as a suggestion it is said that better namings should be used in order to make better understanding in the users' minds. Another good point was raised about the single handed use of mobile. It was noted that when one of the problems in the earlier version was when users were given a specific task, the input fields were spread on the screen rather than having a single side. It was suggested that whenever it is required to take the input from the user, the right side should be preferred. Moreover, disorganized form fields were messy in the mobile application and it was found difficult by the users to fill the forms. The input fields should be consistent in vertical layout so that users can think of the next step on the next line consistently. Another problem found was the small area of tapping which can lead to users not returning to the application if they don't have good experience the first time(as it can become difficult for the users with fat fingers to tap). It was suggested to make the selection fields larger to an extent

which is suitable to the user's finger-tip tapping.

Another study by Hertzog & Torrens (2004) where provides the approach of context-aware computing on travel assistant apps using User task Modal in which the idea was to help the user to be able to change their decision while planning the travel. It is really helpful in usability although this study's prototype was given at a non-smartphone PDA (Personal digital assistance) device.

Another study old yet worth telling about done by Burmistrov (2009) where it was told that mobile air ticket booking itself is a cognitively complex task due to which some guidelines were presented and a prototype was provided to show these guidelines in action and try to make the process simple. The prototype provided was yet in non-smartphones as at the time of this study the old mobile phones were the ones having most users as already mentioned by Burmistrov (2009) also. But the guidelines can still be helpful in smartphones related to easiness of the steps of booking.

## **2.4. Universal design of mobile applications and web and issues related to existing guidelines**

Talking about universal design on mobile devices, it's a big challenge actually to follow all standards on mobile applications specially for airline ticket booking due to its already complex nature and requires a lot of input by the consumer (Burmistrov, 2009). There are many studies on making the mobile applications more accessible and usable showing that there are still problems which are not tackled properly, and researchers are trying to focus on that and solve user problems with respect to different domains. Universal design is defined by Fradj (2013) as “a concept that tries to make minorities' life, especially persons with disabilities, better: not only by destroying physical barriers but also by trying to include them socially”. Accessibility is a major part of universal design and Mobile accessibility specifically is defined by WCAG as “making websites and applications more accessible to people with disabilities when they are using mobile phones and other devices”. Tigwell et al. (2018) mentions that guidelines are treated as suggestions instead of proper

guidelines by some stakeholders and it was also said that there are two important things to make the students aware of accessibility 1. “students must get engaged with some practical development like a mobile application.2. Students must be concerned about the person having disabilities so that they can focus and do more because the guidelines will be more meaningful to them. Tigwell et al. (2018) found from their experiments through their participants that there are positive and negative perceptions about accessibility. The negative perception was given with the reason that it affects a small number of people however it takes a lot of cost and it was seen as compromising the design. The positive aspect they got from their study was that accessibility benefits all types of user not only the ones who are disabled in some way.

Power et al. (2012) while studying accessibility problems by blind users on the web found that only 50.4% of the accessibility problems encountered by blind users are covered by WCAG 2.0. Siebra et al. (2015) found that there is still a need for a high variety of external devices which achieves accessibility and more research to provide better accessibility to those devices. Ballantyne et al. (2018) noted that the usage of external accessibility devices is not enough if the developers are not following the certain guidelines and criteria to make that external device to work correctly with the application. As a fact might not be related directly to our study but Siebra et al. (2015) did a survey on accessibility devices for mobile applications and noted that there are a greater number of applications (to integrate with the accessibility devices) on iOS platform than Android related to visual impairment specifically. 100 popular android apps were checked, and it was found that all of them have one out of nine accessibility errors (Ross et al., 2017).

Coming to another example done by Tigwell et al. (2018) on SVI (situational visual impairment) design to find how it can be resolved. Situational visual impairment is defined by Usability First (n.d.) as ‘a difficulty accessing computers due to the context or situation one is in, as opposed to a physical impairment. Examples include noise, poor lighting, distractions, other tasks that require use of hands or eyes, and social constraints such as the inappropriateness of using devices with audio when attending a lecture’. Gong et al. (2012) according to which the ambient light(natural



light) has effect on mobile devices and it is difficult to use as it is increased. According to them existing guidelines are not enough for coping with SVIs.

Including more people is harmful in the design process and Clients do not like it if the designers raise the point of accessibility (Tigwell et al., 2018). One of the reason noted by Tigwell et al. (2018) to not follow WCAG guidelines and sometimes follow other guidelines like the ones made by Apple is due to the more technical language used in WCAG and they can't be trusted if they are not written in an expected and simple way(of stakeholders) as perceived by the study findings. One of the participants of Tigwell et al. (2018) focused upon the user feedback in order to find the usability problems earlier in the process. The reason to not achieve accessibility by designers can be because of lack of awareness to them (Tigwell et al., 2018) . Good suggestion was given by the participant of Tigwell et al. (2018) about imposing accessibility on gaming applications for App Stores like Google and Apple stores by these platforms saying that applications can't be featured or promoted if they are not accessible(and then can also be applied to other types of applications).

Design tools can be helpful which can reduce the need to read the guidelines in detail (Tigwell et al., 2018). ACE ( Accessible Colour Evaluator) was designed by Tigwell et al. (2017) which allows web designers and developers to have a balance in aesthetics and accessibility constraints.

while studying the web accessibility for older users (Arch, 2009) have mentioned the reason for not utilising the current knowledge of accessibility is that people are not aware of it. In Norway, after the Universal design law came into effect in 2013, there were still 75% of organizations not following it due to lack of knowledge of its existence (*Digitalisering for Alle?*, 2014) mentioned by Halbach & Fuglerud (2016) which means there was a need of making people aware of it. Getting older means more functional impairments like visual, hearing, physical, neurological, and cognitive impairments (Halbach & Fuglerud, 2016). According to World's Older Population Grows Dramatically (2016) report in 2016 there were 8.5 percent aged 65 and above which is expected to grow to nearly 17 percent by 2050. The Web Accessibility Initiative: Ageing Education and Harmonisation (WAI-AGE) project is

the source who are trying to help people understand the special requirements of older web users to achieve universal accessibility (Halbach & Fuglerud, 2016). Developers in addition to follow the WAI guidelines also need to create usable environments for the people who are using specific external assistive technologies (Halbach & Fuglerud, 2016).

Another domain noticed by Schefer et al. (2018), they made some guidelines for social networking apps for deaf users showing that guidelines are available (WCAG guidelines) but developers find issues fulfilling some users' needs.

Sa-nga-ngam & Kurniawan (2006) found problems for older users related to web browsing which are 1. undesired content (like advertisements, pop-up windows, spams

and promotional emails) 2. Connection problems (like slow connection or security problems in insecure network) 3. Missing pages (like 404-Not found pages) 4. Some sites do not work on all browsers 5. Poor design and 6. Forcing users to do an action (like forcing users to register).

Sayago & Blat, (2007) found problems for older users when they do advanced search due to information overload. As we already mentioned that flights booking applications are complex in nature (Burmistrov, 2009) so this should be made as simple as it can be.

Coming towards testability of WCAG guidelines, As WCAG claims that all the WCAG criterias are testable but many of the scientific population does not agree to this due to which there are many methods of testing and measuring these criteria by WCAG related to Universal design (Halbach & Fuglerud, 2016). Halbach & Fuglerud (2016) mentioned about standard of W3C-EM guidelines are the initiative by W3C where they have provided some rules about how to evaluate and test the accessibility of websites, mobile websites and applications (*Website Accessibility Conformance Evaluation Methodology (WCAG-EM) 1.0*, 2014). WCAG-EM is also suitable for Universal design assessments and its applications should be used in future methods of assessments (Halbach & Fuglerud, 2016). Related to the same issue, the

organization of Difi in Norway have also made some effort in making some set of quality criterias to assess digital services and websites related to accessibility and usability. They are well defined but fewer than the complete WCAG test suite (Halbach & Fuglerud, 2016).

According to Leitner et al. (2009) some users are not challenged by limitation of technical accessibility but more due to cognitive disabilities which are not covered by WCAG accessibility guidelines, however it should be. It was also mentioned by Leitner et al. (2009) that old people are not only facing problems due to their age but also due to the misperception of the patterns of usage as they are the ones shifting from newspaper to modern technology to acquire information.

It is said by Leitner et al. (2009) that the technical specifications are considered as basics and the facts which can't be changed and he suggests that it will be a more correct way where the user's perspective is considered from the very beginning to make the web more accessible. It is suggested by Leitner et al. (2009) that participation of experts such as usability experts while designing of the system and technical requirements can be useful to create accessible interfaces.

## **2.5 Universal design and issues with other e-ticketing systems and m-commerce/e-commerce**

Different studies have been done which studies the behaviour of smartphones on travel. Smartphones create positive impacts on travel. As Jamal & Habib (2020) states the fact that smartphone applications provide useful and live information on the route the user has chosen while traveling, such as warnings on congestion and delays of public transport.

Julsrud & Denstadli (2017) while studying the use of smart devices impacting attitude towards public transport mentioned that it is important to improve experience for the most active smartphone users who might develop a negative attitude towards public transport.

Balaji & Kuppusamy (2016) evaluated the accessibility of indian railway website systems and according to them following the accessibility guidelines not only

benefits the person with disabilities but also the elderly people. The study evaluated the websites using some of the accessibility evaluation tools like WAVE, Checker, EvalAccess. Suggestions were provided after finding the problems according to evaluation done by WCAG 2.0 like providing alternative texts for images which should be semantic, providing consistent technique of tab index navigation, giving the option to the users to change foreground and background problems and other accessibility issues were found related to the guidelines provided in WCAG 2.0. It was noted that no audio was provided for verification of captcha used in the website which should be provided in order to provide the user with disabilities a more easy way to verify the through captcha. Three parallel <marquee> tags were used on the page with different orientation and different colors making it difficult to read.

Leitner et al. (2009) while studying "User requirement analysis for a railway ticketing portal with emphasis on semantic accessibility for older users" mentioned that it is the users who defines the requirements and they consider those requirements as standard which are not only related to coding but also about using the same kind of websites at same patterns. It was found by Leitner et al. (2009) that in order to optimize the usage of older users on online systems, it is not only important to provide the system with technical accessibility requirements but universal technical requirements. According to Leitner et al. (2009) railway companies need to obstruct a lot of barriers in order to show the important information to the users such as timetable information, ticket, journey plan and other related information. Leitner et al. (2009) mentions that the difference in usage of ticketing systems by older people is not due to their needs and preferences but it is according to the experience of using the medium or specific service. It was suggested in their findings that advertisements that mislead the users should be replaced by useful information on travel offers and alternative travel options. It was found that older users want to use the system to get a lot of information like comparing prices, travel opportunities and other related information. It was found that the steps in the design of online ticket solutions should be described properly as the older users suggest and especially the step of payment and review of data.

Hussain et al., (2017) studied the usability of the Mudah.my on Mobile Device

covering the aspects of efficiency, effectiveness and satisfaction. Usability is defined by ISO 9241-11:2018, Ergonomics of Human-System Interaction — Part 11 Usability: Definitions and Concepts (n.d.) as “the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use”. Mudah.my is an online ads-based website in Malaysian market where one can sell and buy their new and used items. The app was found easy to use but there were some usability issues with the app. After usability testing it was found that mudah.my is 80.25 % effective which shows the high rate of users completing their tasks, with 81% of efficiency which shows the high rate of users completing their goals in less time with 79.19 % of satisfaction rate showing users feel comfortable with the interface. This gave 80.21 % of usability to the app which showed that the app is usable however some recommendations were provided after usability testing according to which there should be a proper filter method through which only the searched and relevant item results are displayed, there should be simple ways to complete important tasks. Also recommended was that the list of locations should be shown alphabetically. This is an important factor as it will help users to search easily.

## 2. Methodology

We have chosen to go for the hybrid methodology for our research because it is the most suitable approach as we can't only rely on the quantity of the result but we need the quality of response so that we can analyze better with a diverse set of data in order to produce better results. According to "Hybrid Research" (2019), hybrid methodology is not only the mixture of quantitative and qualitative methods but it is more than that and it can be a combination of multiple research methods, for example in-personal plus digital methods. Here are some benefits of hybrid research methodology:

- Gives better connection for future research as it can become relatable from one question to another research question ("Hybrid Research," 2019).
- It saves time and cost if used concurrently ("Hybrid Research," 2019).
- Gives better results as different methods and ways of data collection are being used, giving us a better and in-depth story of the situation ("Hybrid Research," 2019).

This method is designed to get most out of both qualitative and quantitative methods.

The hybrid method gets the result on the deepest level in which quantitative data are obtained and then those results are analyzed in a quantitative way giving better understanding and results validity ("Hybrid Methodology Promotes Better Results," 2019).

The qualitative research can get agile by following hybrid methodology. The projects can be done faster by getting specific thoughts of the target audience ("Hybrid Methodology Promotes Better Results," 2019).

It is argued by Maxwell (2016) that combining the qualitative and quantitative methods can be very useful to the mixed method researchers in getting their conclusions from research.

We are planning to do some expert testing along with user testing for getting the evaluation data both for accessibility and usability. For accessibility testing we will also check with some automatic testing tools which we can help ourselves in making the results more reliable and we can also consider the results of automatic testing as the starting point of manual testing. For user testing we are using google forms as they will provide us with an anonymous collection of data. We are going to use a mix of likert scale type of questions and open questions to have better quality of the results. "The Likert scale is a five (or seven) point scale which is used to allow the individual to express how much they agree or disagree with a particular statement" (McLeod, 2019.). According to Nemoto and Beglar (2014) it is beneficial to combine both likert-scale and other data collection methods in order to get better results and in-depth understanding. We will try to maintain the quality of our results as best as possible by using some qualitative open questions as those give more explanatory results with reasons and solutions, which is actually one of the benefits of qualitative research methodology.

WCAG 2.1 principles will be used as the base for accessibility testing purposes. "Web Content Accessibility Guidelines (WCAG) 2.1 covers a wide range of recommendations for making Web content more accessible. Following these guidelines will make content more accessible to a wider range of people with disabilities" (Web Content Accessibility Guidelines (WCAG) 2.1, 2018, June 05). WCAG principles provide success criterias for each guideline and they also provide some techniques on how to meet those criterias with some exceptions when it is not necessary to meet the success criteria. We will not use full generic rules which are more for the web content but the additional success criterias which are there for meeting the mobile accessibility, as we are not evaluating the web application but a native mobile application. Before WCAG version 2.1, in the version 2.0 which provides some insights and success criteria in order for testing mobile apps. We will put in the list of unique criterias among both these versions and test them.

The seven universal design principles provided by North Carolina State University (NCSU) will be handy in our testing and evaluation process.

These seven principles were developed in 1987 by a group of architects, product designers, engineers and researchers which were led by Ronald Mace(late) in North Carolina State University (NCSU) (*The 7 Principles | Centre for Excellence in Universal Design*, n.d.) . The purpose of these principles is to provide a better understanding of design of products and environments. The principles provided by them can be applied to access the existing design, guiding the design process and how to make new design and products more usable (*The 7 Principles | Centre for Excellence in Universal Design*, n.d.).

We have chosen three airlines mobile applications i.e. Norwegian Air, SAS(Scandinavian Airlines) and KLM.

Norwegian air is the largest airline in Scandinavia and one of the low-cost airlines, at fourth number to be precise. It is the ninth largest airline in Europe with respect to the number of passengers (“Norwegian Air Shuttle,” 2020). Norwegian was on top of our list while deciding for the apps to be tested.

SAS(Scandinavian Airline System) which is commonly known as Scandinavian Airlines. It is a flag-carrier for three countries i.e. Denmark, Sweden and Norway (“Scandinavian Airlines,” 2020). The airline has its main hub at Denmark airport of Copenhagen-Kastrup with second and third largest hub in Sweden at Stockholm Arlanda Airport and Norway at Oslo Airport, Gardermoen respectively (“Scandinavian Airlines,” 2020). This shows the importance of our selecting this app to test it.

KLM, abbreviation of *Koninklijke Luchtvaart Maatschappij*, airline is national airline of Netherlands, literally “Royal Aviation Company” (“KLM,” 2020). It’s headquarter is in Amstelveen and a hub near Amsterdam airport, Schipol (“KLM,” 2020). KLM was founded in 1919 and is the oldest airline in the world (“KLM,” 2020). As per 2015 they had 35,488 employees and 119 fleet (“KLM,” 2020). They operate scheduled services to 145 destinations including passenger and cargo

Norwegian Air and SAS are two of the most used airlines in Norway (“Norwegian Air Shuttle,” 2020) (“Scandinavian Airlines,” 2020) and the KLM is one of the most used



around the world. As we have three applications, it is hard to get each participant to test all three apps. So we will try our best for each app to be tested with a good number of participants in order to get comparable results. For this we have thought about getting as many participants as possible and we will not make it mandatory for each participant to test all three apps and fill the survey three times, but it would be their own choice. So, getting a good number of participants will help us in getting all three airline applications tested. We have two sections in our survey, the first one is the consent. If the person wants to participate he/she will agree with the consent and continue to the second section which is the actual survey (set of questions to get the response of participants regarding usability). If a user disagrees with the consent then he/she will not be directed to the second session but instead will be directed to the end which is the submission page or the user can simply close the window.

We made the set of questions for user testing for testing some very common and important functionalities. We made the survey so that the user can go through the important steps to let us know about what they think about the usability of the apps. This is important because we will get the qualitative results by getting the real answers from real users out there. We define real users out there the ones who use mobile apps on a daily basis and do not feel this as something new.

### **3. Ethical considerations**

Our plan is to not collect any personal information from the participants. It was difficult to get quality results by constraining ourselves from not obtaining any data which can personally identify any person, as in our case recording the user's experience would have helped us a lot. We needed quality results as it is not easy to evaluate the popular apps which kind of acts as a blueprint for other companies to design their apps according to (bigger companies strategies are often followed by new and small companies).

We opted for google forms and have chosen the questions that do not help reveal the identity of the person. All the questions we are asking in our survey for user testing have been explained in the section above and the survey will be given in the appendix as well. We asked the consent from the participants and if they agree to participate, only then are they redirected to the survey questions otherwise not. We haven't asked any question by which any participant may not feel good or be insulted in any way, for example asking about their disability or health conditions etc. It is quite easy to have face to face interviews and then record what feedback they have provided so that we could easily analyze everything afterwards, but we are not doing that as audio recording can also identify the participant which is not ethical and is a breach of their trust and violation of their privacy. Only technical, user-centric and easy-to-understand questions are asked in the survey. It is important to keep the survey as easy as possible so that the participants are kept interested and do not leave the survey unanswered. All the data is going to be collected through anonymous means i.e. through google forms and some may also be collected through face-to-face or virtual face-to-face interviews. Consent will be taken from the participants in order to make them feel secure that everything is documented. Any data which can create the sense of discrimination in participants is ignored and will not be collected or asked. Moreover the data being collected will not be misused in any ways. The data which is sensitive to the person is not asked either.

We are taking the participant's consent with the question as follow:

- *I agree to participate in this survey related to student project on testing usability.*
  - Yes
  - No

## 4. Data collection

### 4.1. User testing

We did a survey using google forms for user testing and asked as many people as we could. We are not closing our survey to accept responses but we can start analyzing what people are experiencing. We have gotten 34 responses for all the three apps in total.

The task of booking a ticket was given to the participants and then asked to assess the easiness of the search page.

9 out of 15 norwegian app participants have said that the search page was “easy” or “very easy” to use. 3 of them replied with neutral answers and 3 of them have declared it to be “difficult”.

7 out of 11 SAS app participants said that the search page was “easy” or “very easy” to use. 2 stated it to be “difficult” and the rest two replied with neutral answers.

Coming to KLM app. We got 8 responses for KLM. 7 out of 8 stated as “easy” or “very easy” for this task and 1 responded in neutral answer

Clearly Norwegian loses the race in this part for being easy or the simplicity of the search page.

When asked about whether it was easy to navigate between the results of the search or not we got different answers as it was an open question.

We will put these answers in the tables below for each individual app. Shown in table 1, 2 and 3 below:

*Table 1: Answers for the Norwegian app for question "In the search results page, is it easy to navigate through the different available options of tickets ? How do you like the results page? Tell us about your experience in own words:*

<b>NORWEGIAN</b>
------------------

Not a user friendly app. And also I didn't get the option for language setting

Not complicated

it easy to navigate through the different and result page contained summary

Yeah it was pretty easy .. everything was written pretty clearly and in a readygood order.. easy steps. I really like it

No not easy to move , result page is overloaded with a lot of information on sides and filter is like congested

All the important information is given with the illustrations. Satisfied experience.

London Heathrow was not an option available , only London Gatwick or London - All airports, so I chose that (all airports). Easy to navigate through the options of tickets. Results page is ok (I am familiar With it). Experience fine, no problems.

It was a well user friendly environment provided. From the option to add children to the option to show a low fare calendar every step was simple and clearly understandable.

Norwegian's app seems a bit buggy, I selected available routes but was redirected to top saying "No routes chosen". On 3'rd attempt I got it right. Also if you select next day on return route, you get redirected to top again, i think my mother would have big problems understanding what is happening.

Page is ok but only one flight so not much navigation. Informative.
I have tested Norwegian's app, and I find it very good in terms of UX, compared to SAS or KLM
Yes
Result page needs to be adjusted as on mobile this is too much information on a single screen. Should be given a separate view to see details for the all other available tickets.
Not good
Results page is pretty cool. The color scheme is all consistent with the Norwegian flag colors which gives a personalized look and feel to the overall application.

Here the reason for more positive answers and less negative can be the difference between the level of users actually. Issue was raised about the language option not provided which seems a valid point as maybe the user was trying to find the language change option at the same page but to change the language you had to go to another menu and then come back to the page you were viewing earlier which is cumbersome and not user-friendly. We got another result saying that the page was very much overloaded which can be agreed actually. We got useful feedback here as one of the participants says *“Norwegian's app seems a bit buggy, I selected available routes but was redirected to top saying "No routes chosen". On 3'rd attempt I got it right. Also if you select next day on return route, you get redirected to top again, i think my mother would have big problems understanding what is happening.”* Rest of the answers were quite positive and satisfied as most users said that it was easy to navigate on the page.

Similarly for SAS and KLM the answers are below for the same question in table 2

and table 3:

*Table 2: Answers for the SAS app for question "In the search results page, is it easy to navigate through the different available options of tickets ? How do you like the results page? Tell us about your experience in own words:*

<b>SAS</b>
Very easy and friendly interface.
yes
The actual search process (filling in options) was easy, but when clicking the search button, I got a message that I was required to log in and that I had to be logged in to search for flights. I had forgotten my password and had to reset it, which I did, but the app did not accept the new password, etc. so in the end I just gave up - too much hassle to search for flights...
Easy
Easy to navigate options, can also easily see return options before choosing outbound
Not very user friendly and the app is slow
Yes. It was easy
Didn't get incontext login option when searching the flight. Login just to see the search results is bad experience. Over all search expeience is OK.
Navigation was easy but font is small colors are not that attractive
Not good

Overall, I don't like the look and feel of this page especially in terms of colors. The grey colors look dull to me and that could've been better.



Table 3: Answers for the KLM app for question "In the search results page, is it easy to navigate through the different available options of tickets ? How do you like the results page? Tell us about your experience in own words:

<b>KLM</b>
Poor experience
best of the lot
very easy and understandable (options, times, price starting point)
Easy
Easy to see outbound options but can't see return before choosing outbound
Fast and friendly
Complete process was very easy and user friendly
It has all the necessary information on the screen which is easy to view and navigate through making it an application with aesthetic design.

In reply to our next question "How easy it is to fill in your required information and choose the optional services in addition to your ticket? For example, fast-track security check, extra baggage, travel insurance etc", 12 out of 15 Norwegian app testers said that it was "easy" to fill in information, one saying "very difficult", one saying "difficult" and for one it was neutral.

6 out of 11 SAS testers have declared it easy but four said as neutral and for one it was "very difficult". Similarly KLM testers here where 1 out of 8 are neutral and 7 answering "easy" or "very easy" to this question.

When we asked about whether it was easy to view all the information on the summary page, according to 3 out of 15 testers for the norwegian app there was no summary page which is true, 1 said it was not easy, the rest saying it was easy. It can be due to the different understanding of the summary page to the participants . Not a good sign for these kinds of applications to not have an easy to understand full summary page where users can view all the important information at once which can lead to less number of requests to change or remove anything from the booking for the airline companies after the order is confirmed. 3 out of 8 KLM participants said it was not easy, while 4 said it was easy and for 1 there was no summary page at all. Going with the majority we reached to the point that it is easy to view the summary page. Coming to SAS we don't have a summary page at all, at least not before payment. Until now only two participants have realized that there was no summary page actually, rest of them saying it was easy and the reason for it could be the different understandings/experiences of what the summary page is exactly. SAS has made their app in a way that we select everything at one place in a nice way and then we go directly to the payment, hence no separate page for reviewing our entered information once more.

Following the last question we asked the follow-up question which is why do they think it was easy or not easy to view the information. Combined with the last question, following are the different answers in table 4 we got from all three airlines and to get an overview of all answers from all three airlines.

*Table 4: Answers of all the apps for question about whether it was easy view to summary page with all information and the follow-up question why or why not it was easy*

<b>App</b>	<b>Do you think all your ticket information like fast-track security check, extra baggage etc provided on the summary page are</b>	<b>As part of the last question, why do you think it was not easy or easy to view information on the summary page?</b>

	<b>viewed easily ?</b>	
SAS(Scandinavian Airlines)	Yes	They provide you information with all the important things.
Norwegian	Not applicable (summary page not available on the app being tested)	I can't even succeed in making acc
KLM	No	I didn't understand the app
Norwegian	No	Wasn't mentioned all the info.
Norwegian	Yes	Yes
SAS(Scandinavian Airlines)	Yes	yes
KLM	Yes	it was well organized
Norwegian	Yes	They have all steps in a good order
Norwegian	Yes	Yes it is easy to view
Norwegian	Not applicable (summary page not available on the app being tested)	There was no separated summary page given. After the last option i was directly to the payment. Summary was given

		under every page during the process. But that was long way under the form.
KLM	Yes	right amount of details (not too much)
SAS(Scandinavian Airlines)	Not applicable (summary page not available on the app being tested)	I never managed to log in, so the answers are not valid..
Norwegian	Yes	Concise (not too much information), not necessary to scroll sideways or similar.
Norwegian	Yes	From the pictorial representation to the description all the details were present when the package was being selected between lowfare, lowfare+ and flex.
Norwegian	Yes	Easy
SAS(Scandinavian Airlines)	Yes	Very easy
KLM	Yes	Easy
Norwegian	Yes	Easy because summary

		was available before entering passenger information
SAS(Scandinavian Airlines)	Yes	Collapsible elements with details available without going to a separate page
KLM	Yes	Clear
Norwegian	Yes	It was easy to see the summary info and distinguish between departure and arrival because of the card/box design, placing departure info in one box and arrival info in the other
Norwegian	Yes	It was easy to use
SAS(Scandinavian Airlines)	Yes	It was alright
KLM	Not applicable (summary page not available on the app being tested)	-
Norwegian	Yes	It was easy because this will give an overview on how much baggage is allowed with hand carry.

SAS(Scandinavian Airlines)	Yes	It is easy as every option is there
SAS(Scandinavian Airlines)	Yes	Information was to the point.
KLM	Yes	I managed to book ticket very easily so this KLM app is very user friendly
SAS(Scandinavian Airlines)	Yes	Font is small. Currency is in euro regardless like klm
Norwegian	Yes	Easy
SAS(Scandinavian Airlines)	Yes	Easy
SAS(Scandinavian Airlines)	Not applicable (summary page not available on the app being tested)	Not Applicable
Norwegian	Yes	The information on summary page is easily viewable because of the balanced use of icons and corresponding text which is a good design practice.
KLM	Yes	The updated design of this app makes it easy for the users to view all

		necessary information on the summary page.
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In the next question we asked about the seat selection process whether it was easy or not and then right after it in the next question we have asked them the reason about it being easy or not. Both questions with their answers are given below in table 5:

*Table 5: Answers of all the apps for question about whether the seat selection process was easy or not and the follow-up question why or why not it was easy*

<b>App</b>	<b>Do you think the seat selection process was easy to use ?</b>	<b>As part of last question, why do you think the seat selection process was easy or not easy to use ?</b>
SAS(Scandinavian Airlines)	Yes	They showing the seats selection
Norwegian	Not applicable (airline app being tested does not have this feature while booking)	Didn't get to use the app! Language issue
KLM	No	Didn't understand the app
Norwegian	No	You have to pay extra fee to book in advance your seat.
Norwegian	Not applicable (airline app being	not really available or I couldn't see find it

	tested does not have this feature while booking)	
SAS(Scandinavian Airlines)	Not applicable (airline app being tested does not have this feature while booking)	I was not able to find the seat selection area
KLM	No	n/a
Norwegian	Yes	I just had a really good experience with every step in the norwegian airlines
Norwegian	Yes	Yes it is easy.
Norwegian	Yes	It showed the illustration of the place, which makes it easy to imagine the seat.
KLM	Yes	maybe the use of colours showing which seats I could choose (and which type of seat), and that the seats were shown as if seeing the Aircraft from above? (And no seat numbers shown)
SAS(Scandinavian Airlines)	Not applicable (airline app being tested does not have this feature while booking)	I never managed to log in, so the answers are not valid..



Norwegian	Yes	Show the seats as seeing Aircraft from above.
Norwegian	Yes	All the details were clearly mentioned in the app during the booking so there was no query left and I found the whole process easy.
Norwegian	Not applicable (airline app being tested does not have this feature while booking)	Was not able to test now, but on Norwegian I think you need to buy a ticket first to use seat reservation, I have used this many times before and I found it easy to use.
SAS(Scandinavian Airlines)	Yes	Very easy
KLM	Yes	Yes, but it said "Free", then you go into it and only some seats in certain planes are free, not *all* are free. :(
Norwegian	Not applicable (airline app being tested does not have this feature while booking)	NA
SAS(Scandinavian Airlines)	Yes	Because it works as expected
KLM	Yes	Works as expected

Norwegian	Yes	I do not see how this part can be difficult
Norwegian	Not applicable (airline app being tested does not have this feature while booking)	-
SAS(Scandinavian Airlines)	Not applicable (airline app being tested does not have this feature while booking)	-
KLM	Yes	Fast and suggestive
Norwegian	No	It was not easy because it should highlight somewhere that these seats are available and not available.
SAS(Scandinavian Airlines)	Yes	Easy as visuals are provided
SAS(Scandinavian Airlines)	Yes	Graphical view of plane makes it easy to imagine the seat.
KLM	Yes	because I easily selected my seat
SAS(Scandinavian Airlines)	Yes	It is easy and same as other seat selection apps

Norwegian	No	Not easy
SAS(Scandinavian Airlines)	No	Not easy
SAS(Scandinavian Airlines)	Not applicable (airline app being tested does not have this feature while booking)	Not Applicable
Norwegian	Not applicable (airline app being tested does not have this feature while booking)	N/A
KLM	Yes	The app clearly shows the available and booked slots making it easier for the users to choose.

6 out of 15 norwegian app testing participants actually neutrally stated that this question was not applicable because they do not have the seat selection process or due to some other reasons e.g. *“Was not able to test now, but on Norwegian I think you need to buy a ticket first to use seat reservation, I have used this many times before and I found it easy to use.”*. 3 of the participants replied with “No” and according to one of them the reason was he/she had to pay extra to select a seat which is actually not related to the usability issue but according to the participant it was not a nice feature and one of the participant replied with no says that the app was not highlighting that which seats are available and which are not. Rest of the 6

norwegian app participants declared it to be easy for all good reasons as can be seen in the data table above.

6 out of 11 SAS airline app testing participants found the seat selection process easy for good reasons. While 4 of them answered as “Not applicable” as one of them said that the app didn’t show the seat selection and the other was not able to log in and continue. A bad experience with SAS is that you must need an account and must be logged in to use the app and search your flights. To 1 participant, the seat selection was not easy.

2 out of 8 KLM app testing participants said it was not easy with one of them giving the reason that it was not applicable and the other participant said that he/she didn’t understand the app. Rest 6 participants said that it was easy with good reasons. One of the good reasons by the participant was “*maybe the use of colours showing which seats I could choose (and which type of seat), and that the seats were shown as if seeing the Aircraft from above? (And no seat numbers shown)*”. One of the participant while saying that it was easy but also stated a problem as “*Yes, but it said "Free", then you go into it and only some seats in certain planes are free, not \*all\* are free. :(*”

Coming to our second last question where we asked participants to express the overall aesthetics about the application. Among 15 Norwegian app testing participants, we got really interesting answers as shown as follow in table 6:

*Table 6: Answers for the Norwegian app for the question "How do you like the overall aesthetics(or design in simple words) of the application?"*

<b>NORWEGIAN</b>
<b><i>How do you like the overall aesthetics(or design in simple words) of the application?</i></b>
Poor attraction
Good

Good but could've been better
I like it it was super easy
Design is complex.
Satisfied.
It is ok, but I would have preferred simpler, "cleaner" look, With even less information, and maybe more use of colours (it was a lot of grey areas..)
The app is well made. Its a user friendly app. In my opinion everyone can use it without any hurdle. It has all the details which a user needs to know before booking a flight.
It has good aesthetics, I think it looks good
ok but a bit messy and giving a bit disorganized impression
A little dated, sharp edges and very little polished feel with shadows, round edges and regard to white space. Also, I would appreciate a more intuitive date selection alike the one you can find in SAS's app, where you can select departure and arrival dates in the same calendar view.
Alright
Perfect
Design not good
The application possess aesthetic design overall and is interactive. As an end-

user, I found an easy experience while navigating within the application

9 out of 15 participants were satisfied with the aesthetics but the other 6 answers we got were really very informative which informs us about the design being messy and the margin of improvement is huge out there. This will be kept in consideration while we go further in suggesting the area of improvements.

For the same question, KLM app testing participants answers are as follows in table number 7:

*Table 7: Answers for the KLM app for the question "How do you like the overall aesthetics(or design in simple words) of the application?"*

<b>KLM</b>
<b><i>How do you like the overall aesthetics(or design in simple words) of the application?</i></b>
Interface was catchy
very nice design with overall great UX
yes, seems clean and simple
Its good and clean. I like the dark theme!
Good but a bit messy
Really nice
I would rate 10/10
This app is so easy and well-maintained. It is clearly a winner.

We got 1 negative answer here saying “*Good but a bit messy*” out of four answers here. Overall it looks like KLM is far ahead with the aesthetics here among other two apps. This can be concluded based on some very good replies we got from participants as above.

What does SAS app testing participants say is below in table number 8:

*Table 8: Answers for the SAS app for the question "How do you like the overall aesthetics(or design in simple words) of the application?"*

<b>SAS(Scandinavian Airlines System)</b>
<b>How do you like the overall aesthetics(or design in simple words) of the application?</b>
Very friendly interface or design
Design is fairly simple which makes it easy to use however UX could be better
I never managed to log in, so I don't know..
The design looks a bit simple, a bit bootstrapy, but its clean and easy to look at
Quite nice
Not much actually, looks quite unprofessional
Design is very basic. Not a lot of effort is put in order to make it look good
Simple design without extra clutter.
Design is fine but could be improved.
Simple design
I don't like the overall design of this app. The fonts are outdated, there is no use of

proper icons, uneven use of colors.

1 of our 11 SAS app testing participants didn't actually manage to log in actually so we have to rely on the other 10 testers here. According to the limited answers set until now we can say that the design of SAS airline application is quite simple. 1 of the participants stated it as simple and easy to use while others stated the same thing about simplicity while at the same time also mentioning that UX could be better. The need for improvement is there as one of them stated about the outdated fonts, uneven use of colors and no use of proper icons.

Coming to our last question where we ask about the suggestions which participants want to share, We will first see Norwegian app testers results in the following table number 9:

*Table 9: Answers for the Norwegian app for the question "Do you have any other suggestions/problems in the app you tested?"*

<b>NORWEGIAN</b>
<b><i>Do you have any other suggestions/problems in the app you tested?</i></b>
Atleast give option for language selection
No
had some difficulty selecting the routes , there should be radio button which would help users to select their option
I think they doing a good job
No
Additional summary page before the payment is what the norm is. It feels like missing.



No
Just a suggestion that I don't know why but sometimes it takes a few minutes for the book option to load. Maybe Its only happening with me but I just wanted to convey my experience.
I think the "previous/next day" option could be a bit more reactive
Requires passenger information too early to be easy to check final summary page
No
Date selection for ticket could be improved with better color coding.
Yes i have a document and will be sharing with Danial
Impovered app speed
Nope, so far so good!

We got quite good suggestions for the Norwegian app testers. We got 1 participant who was not able to find the language changing option easily. One of the suggestions was given to make the selection of routes easier by providing the radio buttons to be able to select routes properly. The answer goes here *"had some difficulty selecting the routes , there should be radio button which would help users to select their option"*. A very important other suggestion given was *"Additional summary page before the payment is what the norm is. It feels like missing"*. This is a very good suggestion which can be agreed at once. One participant added "I think the "previous/next day" option could be a bit more reactive" which was very nicely noticed by the participant actually. Date selection improvements are suggested through better colors. Speed improvement is also demanded in suggestions.

Following are the 11 responses from SAS(Scandinavian Airlines System) testing participants in table number 10:

*Table 10: Answers for the SAS app for the question "Do you have any other suggestions/problems in the app you tested?"*

<b>SAS</b>
<b><i>Do you have any other suggestions/problems in the app you tested?</i></b>
No its good enough
the option to select dates should be separate for round trips
Allow people search for available flights before having to log in, and make sure people can log in to the app once they have updated their password..
I did not miss anything
Allow booking without being logged in
Improve interface, departure arrival city selection could be done on the same page and faster
Improve design
Login should not be necessary before flight selection.
Increase font, change currency to selected country, show prices for next and previous days as well
Improved app speed

User interface needs some serious overhaul.

Out of 11 SAS app testers we only got 2 positive answers. One of them asks that there should be a separate option to allow for choosing the dates for round trips. It might ease the specific user's task. 3 participants are complaining about not being able to search and book flights without login. One participant complains that it was still not possible to log in if one changes password which is totally understandable as some odd things related to password change were experienced personally as well. Rest of the participants have given some suggestions to improve the overall interface, which will be further discussed in analysis.

Now we will go through the KLM app testers. The responses are shown here in table number 11:

*Table 11: Answers for the KLM app for the question "Do you have any other suggestions/problems in the app you tested?"*

<b>KLM</b>
<b><i>Do you have any other suggestions/problems in the app you tested?</i></b>
No suggestions
all good
no
After you have chosen the dates, you have to choose country code and phone number before the Continue button is clickable. It took me a bit time to realise I had to fill out those forms. It could be done in a better way - or another place (on register user maybe?)

This is a required question? Sounds optional to me...
If the app could have been little faster
For disable people they could add voice feature
I think it's already one of the best airline apps out there.

4 out of 8 of our KLM testers do not have any suggestions to provide here. While 1 tester suggested a very good feature as *“After you have chosen the dates, you have to choose country code and phone number before the Continue button is clickable. It took me a bit time to realize I had to fill out those forms. It could be done in a better way - or another place (on register user maybe?)”*. One would not think of the phone number to be mandatory to be entered while doing a booking always. That might have confused the user here. In the rest of the two suggestions, voice feature and speed improvement is also asked.

## **4.2. Accessibility Testing using WCAG 2.1 and WCAG 2.0**

I did accessibility test myself as an expert test by following the WCAG 2.1 principles which are not all the principles but WCAG 2.1 published these additional success criterias which are addressing mobile accessibility issues plus the WCAG 2.0 special guidelines which shows how WCAG 2.0 applies to mobile accessibility, we will go through all the unique principles one by one from both versions:

### **4.2.1. Guideline 1.3 Adaptable**

#### **4.2.1.1. Success criteria 1.3.4 Orientation (AA)**

Norwegian: fail, SAS: fail, KLM: fail

#### **4.2.1.2. Success criteria 1.3.5 Identify Input Purpose (AA)**

In normal forms it fails instead of the fields which are developed using technologies

like the fields for searching the current and destination city airports. But overall this is failed as both type of forms should be able to identify the purpose when interacting with them.

#### **4.2.1.3. Success criteria 1.3.6 Identify purpose (AAA)**

In the Norwegian app, not all the icons are labelled or identified using the Talkback accessibility feature on android phone. Same for SAS and KLM. Passed partially for SAS.

### **4.2.2. Guideline 1.4 Distinguishable**

#### **4.2.2.1. Success criteria 1.4.10 Reflow (AA)**

All three applications pass this success criteria, as no app is scrolling in multi dimension to view the information.

#### **4.2.2.2. Success criteria 1.4.11 Non-Text Contrast (AA)**

1.28:1 contrast for the Norwegian app tested manually in input boxes which fails this criteria badly.

Approx 1.42:1 for KLM which also fails badly

Tested two places for SAS, one place gives 1.14:1, other gives 11.3:1 which was on the button with white text on it. So I can say SAS passes this partially, hence failed.

#### **4.2.2.3. Success criteria 1.4.12 Text Spacing (AA)**

Not applicable for native mobile apps.

#### **4.2.2.4. Success criteria 1.4.13 Content on Hover or Focus (AA)**

There was no content over hover or focus but it was noticed some additional content becomes visible while filling wrong information or not filling information. But it disappears after filling in the correct information. Passed for all three apps.

### **4.2.3. Guideline 2.1 Keyboard Accessible**

#### **4.2.3.1. Success criteria 2.1.4 Character Key Shortcuts (A)**

Not applicable

#### **4.2.3.2. Success criteria 2.2.6 Timeouts (AAA)**

Not applicable on Norwegian and KLM, SAS fails this criteria very badly.

### **4.2.4. Guideline 2.3 Seizures and Physical Reactions**

#### **4.2.4.1. Success criteria 2.3.3 Animation from Interactions (AAA)**

Not applicable.

#### **4.2.4.2. Success criteria 2.5.1 Pointer Gestures (A)**

Not applicable.

#### **4.2.4.3. Success criteria 2.5.2 Pointer Cancellation (A)**

All three apps pass this criteria.

#### **4.2.4.4. Success criteria 2.5.3 Label in Name (A)**

All three apps pass this criteria.

#### **4.2.4.5. Success criteria 2.5.4 Motion Actuation (A)**

Not applicable.

#### **4.2.4.6. Success criteria 2.5.5 Target Size (AAA)**

All three apps pass this criteria.

#### **4.2.4.7. Success criteria 2.5.6 Concurrent Input Mechanisms (AAA)**

We tested with a wireless keyboard.

It works very nice with Norwegian app, but it does not passes the criteria fully as there were still some problems while searching the flights when we wanted to navigate between the check boxes.

Doesn't work with SAS either as there were problems on the main page with navigating on the button and it works really bad on the search form page.

Doesn't work with KLM fully as well as we were not able to navigate between the header and the content.

## **4.2.5. Guideline 4.1 Compatible**

### **4.2.5.1. Success criteria 4.1.3 Status Messages (AA)**

Not applicable.

## **4.2.6. Some guidelines from WCAG 2.0**

In this section WCAG draft tells how some of the mobile guidelines can apply to mobile. In this section it has been discussed that how some of the guidelines can be specifically applied to the mobile apps with some extra information. We will choose some information and try to find out if that suits us. We will only discuss about the guidelines here which we already haven't discussed above when followed WCAG 2.1 special guidelines for mobile. These guidelines are followed by the working draft from here W3C (*Mobile Accessibility*, February 24, 2015).

### **4.2.6.1 Success criteria 1.6.6 Resize text**

This criteria however is already present in WCAG 2.1 also, but we have been redirected to this after following the proper channel through WCAG mobile accessibility page where they redirected us to both WCAG 2.1 mobile accessibility guidelines which we have done above and also to this page where we have draft of how some guidelines in WCAG 2.0 can be applied to mobiles.

Coming to the guideline itself, all the three apps fail this criteria as we were not able to zoom on any app without using accessibility feature.

### **4.2.6.1 Success criteria 2.1.2 Keyboard Trap**

We already have tested the the guideline 2.5.6 "Concurrent Input mechanisms" above in the section above according to the new WCAG 2.1 guidelines for mobiles. For this we are limited and do not have access to a keyboard to test this

accessibility.

#### **4.2.6.2 Success criteria 2.4.7 Focus visible**

All apps are passed. When we tested with keyboard, the focuses were visible.

#### **4.2.6.3 Touch Target Size and Spacing**

It has been tested through automated testing that the spacing is not 9mm by 9mm on lot of touch targets. But the second part of this suggestion which is that there should be some inactive space between touch targets, that is actually passed by all apps.

#### **4.2.6.4 Easy access to buttons**

According to this working draft of W3C/WAI (2015) there has been a suggestion of “Placing buttons where they are easy to access” according to which the buttons should be placed at the location where they are easy to access.

By using the app, we would say that the SAS app fails this suggestion whereas KLM and Norwegian has the places of the buttons where they are easy to access.

#### **4.2.6.5. Success criteria 3.2.3 Consistent Navigation**

All the apps passed this criteria

#### **4.2.6.6. Success criteria 3.2.4 Consistent Identification**

All the apps passed this criteria

#### **4.2.6.7 Success criteria 3.3.2 Labels or Instructions**

All apps passed this criteria.

#### **4.2.6.7 Success criteria 3.3.5 Help (Level AAA)**

All apps failed this criteria.

#### **4.2.6.8 Set the virtual keyboard to the type of data entry required**

This can't be considered as the type of apps we are testing , each field have alphanumeric input expected, So not applicable for our case.



#### 4.2.6.9. Provide easy methods for data entry

All apps passes this suggestion.

#### 4.2.6.10 Support the characteristic properties of the platform

We tested with the zooming and the font size changes through platform, all the apps seems to follow that.

### 4.3. Automated accessibility testing

We used the android app ‘Accessibility Scanner’ developed by ‘Google LLC’ which is based on Google’s “Material design accessibility guidelines”. All the problems are grouped under the specific type of problem with some examples shown in the form of screenshots.

#### 4.3.1. Norwegian

For the Norwegian app, the accessibility scanner scanned and given the following results:

##### 4.3.1.1. Item label

There are items in the app which might not have labels readable by screen readers. For example following two images shows two items in illustration 1 and illustration 2:



*Illustration 1: Bell image without accessible label*



*Illustration 2: An image without accessible image*

#### **4.3.1.2. Touch target**

There are touchable items having size less than the recommended 48dp X 48dp.

Following two images (illustration 3 and illustration 4) show the example of the items which are less than 48dp x 48dp.



*Illustration 3: A checkbox with size less than 48dp by 48dp*

Height is 40dp here which was the problem.



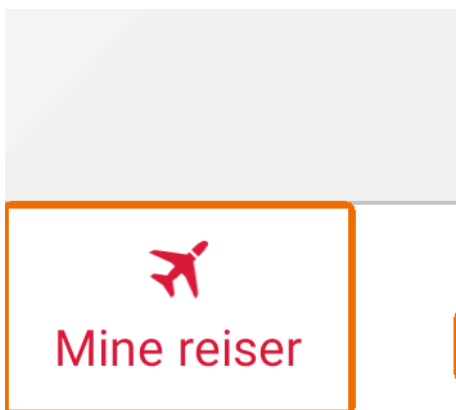
*Illustration 4: A button with size less than 48dp by 48dp*

Size here is 16dp x 17dp.

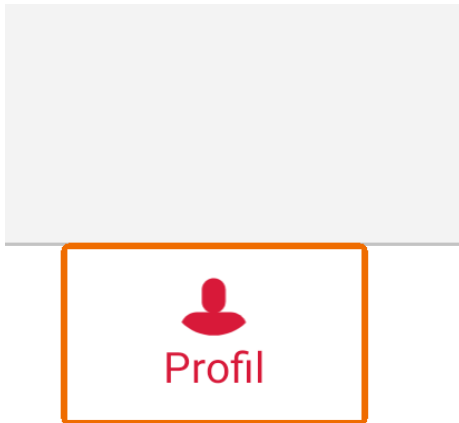
#### **4.3.1.3. Item's description**

There are items having descriptions similar to some other item(s).

For Example, look at the following two illustrations (illustration 5 and illustration 6) showing the items having speakable text similar to that of other item(s):



*Illustration 5: A button shown which has speakable text same as some other item in the app*

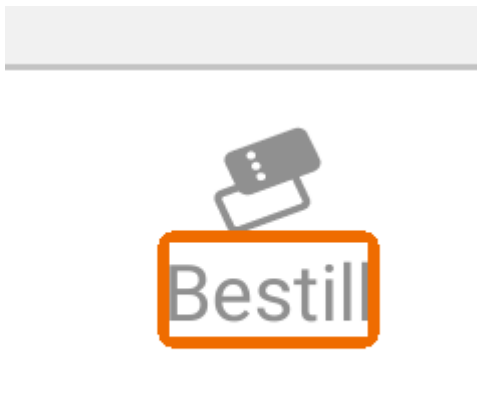


*Illustration 6: A button shown which has speakable text same as some other item in the app*

#### **4.3.1.4. Text contrast**

There are items which are not following the standard text contrast which should be at least 4.50:1.

Following is the screenshot showing an example of this in illustration number 7 (caught by accessibility scanner):



*Illustration 7: Text with contrast less than 4.5:1*

#### **4.3.1.4. Clickable items**

According to the scanner app, there are items which share the same location on the screen.

Following two images(illustration number 8 and 9) shows two items:



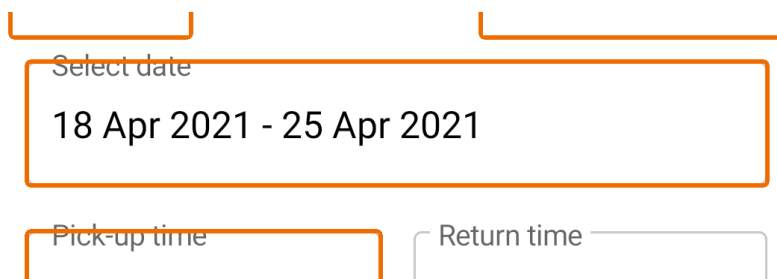
*Illustration 8: An item which shares same location as other items as per automatic testing tool*



*Illustration 9: An item which shares same location as other items as per automatic testing tool*

#### **4.3.1.5. Editable item label**

Scanner scanned the item with the problem of a label of an editable item. According to the app, the editable item has an “*android:contentDescription*” so the screen reader can read this attribute instead of an editable content when the user is navigating. The item is shown as following in illustration number 10:



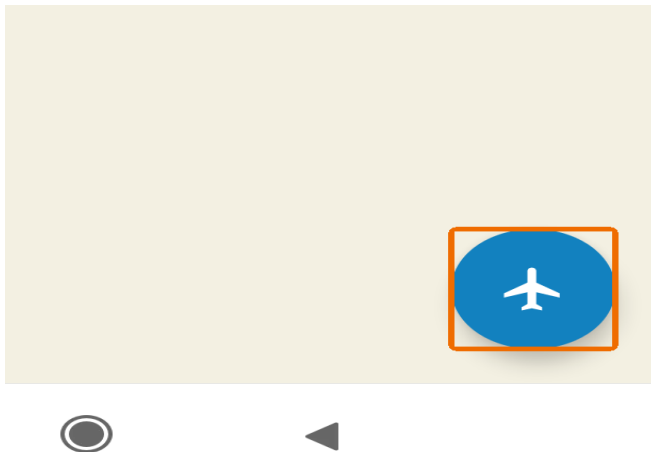
*Illustration 10: An editable field in the Norwegian application*

## 4.3.2. SAS

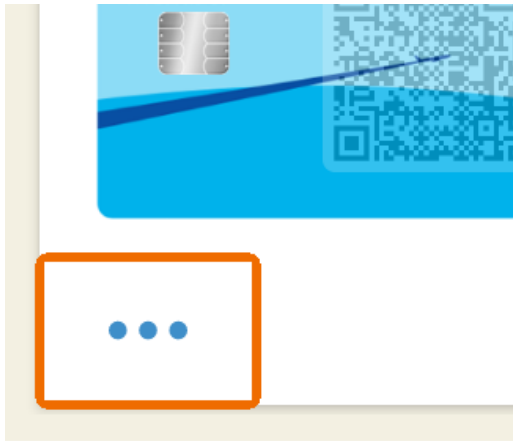
### 4.3.2.1 Item label

Following are the places where Accessibility scanner stated the issue of “**Item label**”

Following three figures (illustration number 11, 12 and 13) show the examples of items which may not have a label readable by screen readers.



*Illustration 11: An icon in the SAS application missing label which can be read by screen readers*



*Illustration 12: An icon in the SAS application missing label which can be read by screen readers*

## RAL APP EXPERIENCE



### APP FEEDBACK

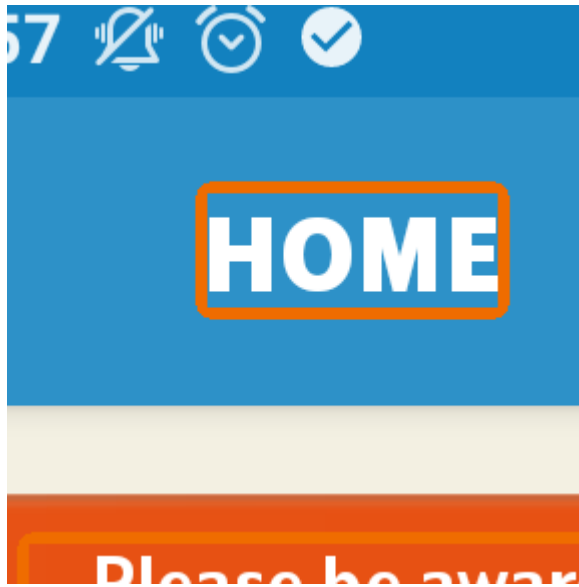
*Illustration 13: An image in the SAS application missing label which can be read by screen readers*

#### 4.3.2.2 Text Contrast

There are items which are not following the standard text contrast which should be 4.50:1.



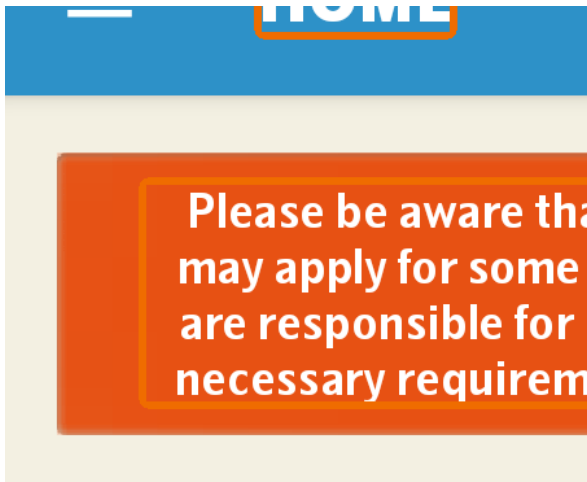
Following are the screenshots (illustration 14 and 15) which are showing an example of this (caught by accessibility scanner):



*Illustration 14: Text having low contrast than 4.5:1 in the SAS application*

As measured by the testing app, the shown item has the text contrast ratio of 3.50:1. According to the suggestion given by the scanner app, it suggests to increase the item's text foreground to background contrast ratio and match the standard ratio of 4.50:1.

The following illustration(illustration 15) shows having the text contrast ratio of 3.76:1 which also does not follow the standard.



### **CHECK IN**

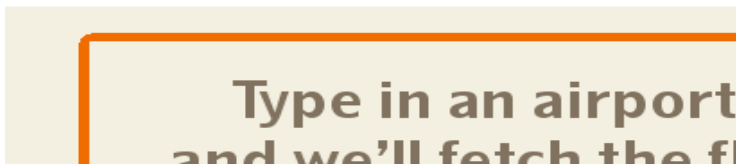
*Illustration 15: Text having low contrast than 4.5:1 in the SAS application*

#### **4.3.2.3. Touch target**

Following are the examples of items which do not follow the standard size if they are touchable items, the recommendation is to have the height of 48dp(device pixels) by Google Material Design Accessibility guidelines.

Following are some examples the scanner app identified as not having the correct touch target size:

The touchable search bar in the following figure(illustration number 16) shown has only the height of 38dp. It should be 48dp or larger.



*Illustration 16: A touchable field having size less than 48dp by 48dp in the SAS application*

The figure following(illustration number 17) has the touch target called “home” having 41dp of height. It should be 48dp or larger

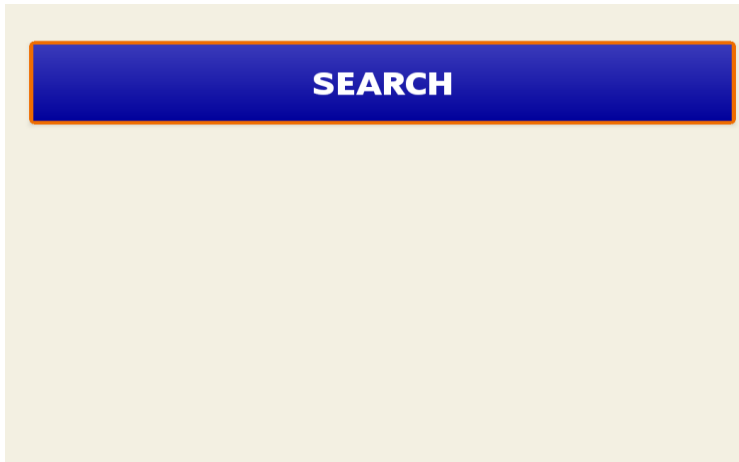


*Illustration 17: A touchable button having size less than 48dp by 48dp in the SAS application*

#### 4.3.2.4 Item's description

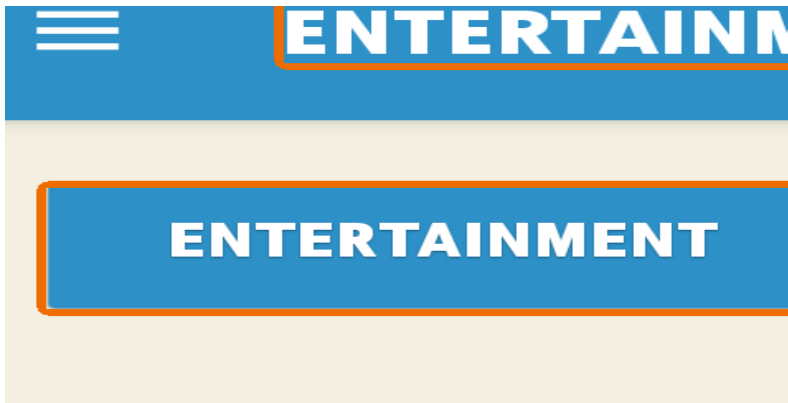
There are items having identical descriptions with other items.

For example in the following image(illustration number 18), the clickable item's speakable text "SEARCH" is identical to that of 1 other item(s).



*Illustration 18: A button in the SAS application which shares the same description as other items as per automatic testing tool*

In the following image (illustration number 19), the clickable item's speakable text "ENTERTAINMENT" is identical to that of 1 other item(s).



*Illustration 19: A button in the SAS application which shares the same description as other items as per automatic testing tool*

#### **4.3.2.5. Image Contrast**

It was suggested by the testing app to increase the contrast ratio between the image's foreground and background.

The image app detected this issue in the following illustration number 20 shown in which the image of stars is the subject. The current contrast ratio is 1.83:1 and the recommended is 3.00:1.

# RAL APP EXPERIENCE



## APP FEEDBACK

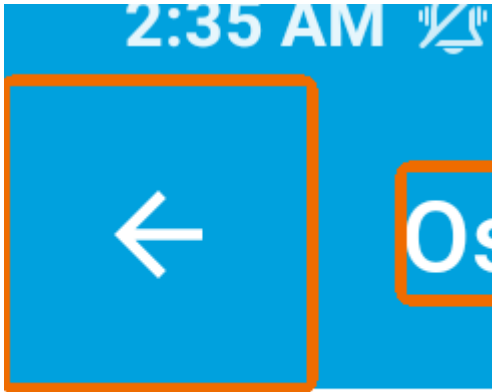
*Illustration 20: An image in the SAS app having low contrast than 3.00:1*

### 4.3.3. KLM

#### 4.3.3.1. Image Contrast

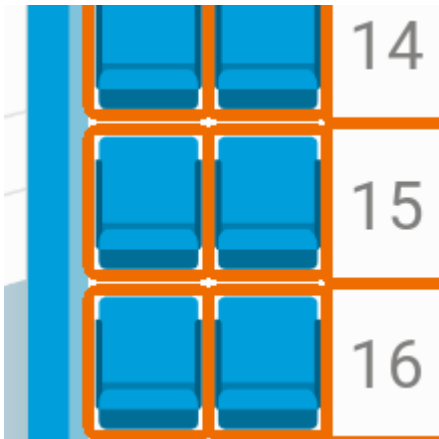
According to the scanner app there are issues regarding the image contrast where it suggests to increase the contrast ratio between the image's foreground and background.

For example, in the following image in illustration number 21, the current contrast between the image's foreground and background is 2.94:1, whereas the suggested is 3.00:1.



*Illustration 21: An image in the KLM app having low contrast than 3.00:1*

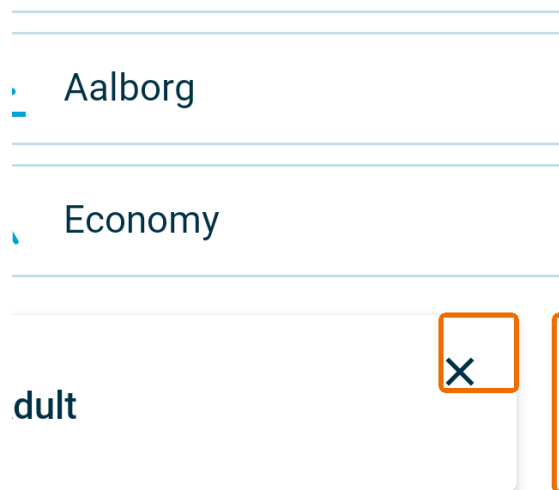
Another example in the seat selection shown below(illustration number 22) where the current image contrast ratio is 2.93:1, whereas the suggested is 3.00:1



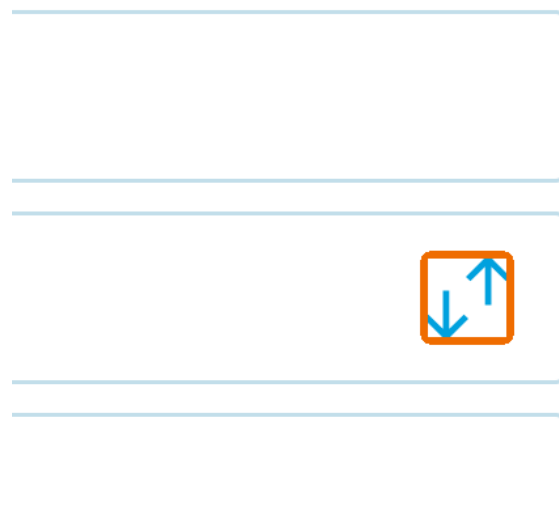
*Illustration 22: An image in the KLM application having low contrast than 3.00:1*

#### **4.3.3.2. Item label**

There are items not having the label which can be read by screen readers. As an example, look at the following two images(illustration number 23 and 24)



*Illustration 23: An item in the KLM app without accessible label*



*Illustration 24: An item in the KLM app without accessible label*



## 4.4. Expert user testing

We will be following Nielsen (1994) heuristics to do usability testing here:

### 4.4.1. Visibility of system status

According to Nielsen (1994) guidelines, this guideline is defined as “*The design should always keep users informed about what is going on, through appropriate feedback within a reasonable amount of time.*”

The Norwegian app gives feedback on errors but the feedback is not that clear as it should be. For example, The app has a red color theme and the error color is also red which is not very clear when one submits the form but due to low contrast between error color and the theme, that error feedback is not very visible to the user. So, this criteria fails on the Norwegian app.

The SAS app also gives feedback on errors. The feedback messages are better than for the Norwegian app. As the contrast between the theme and the error messages color are good enough so this app passes the criteria.

KLM does give some feedback on errors on their forms instantly. Mostly they don't let the users press the button to continue until the user has provided the correct and valid information. So KLM passes this criteria.

### 4.4.2. Match between system and the real world

According to Nielsen (1994) guidelines this heuristic is defined as “*The design should speak the users' language. Use words, phrases, and concepts familiar to the user, rather than internal jargon. Follow real-world conventions, making information appear in a natural and logical order.*”

All the three applications have really good wordings and familiar jargon around which can be understood by most of the people or frequent flying people at least.

### **4.4.3. User control and freedom**

According to Nielsen (1994) guidelines this heuristic is defined as *“Users often perform actions by mistake. They need a clearly marked "emergency exit" to leave the unwanted action without having to go through an extended process”*.

The Norwegian app does not have a back button which is a surprising omission but one can save oneself through the back buttons of smartphones but not all phone software nowadays have a back button but instead use other techniques to navigate back. KLM and SAS at least have back buttons but not their only custom back buttons. So we would say KLM and SAS somehow pass this criteria but I would go against Norwegian in this.

### **4.4.4. Consistency and standards**

According to Nielsen (1994) heuristics for user testing, this heuristic is defined by Nielsen Norman group as *“Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform and industry conventions.”*

According to our experience, all the three apps are quite consistent with the real world air ticket mobile bookings. According to our testing and the data we got from users, all the apps are quite consistent with their choice of wordings and it matches the manual/physical way of ticket booking. The same words are used when booking a ticket physically from a travel agent or airport desk.

### **4.4.5. Error prevention**

According to Nielsen (1994) heuristics for user testing, this heuristic is defined as *“Good error messages are important, but the best designs carefully prevent problems from occurring in the first place. Either eliminate error-prone conditions, or check for them and present users with a confirmation option before they commit to the action.”*.

Norwegian and SAS do have good and understandable error messages, but they do not have error prevention. KLM does a very good job in error prevention. They don't

let users press a button without entering data on any form and don't let users enter invalid data.

#### **4.4.6. Recognition rather than recall**

This heuristic according to Nielsen (1994) heuristics, is defined as *“Minimize the user's memory load by making elements, actions, and options visible. The user should not have to remember information from one part of the interface to another. Information required to use the design (e.g. field labels or menu items) should be visible or easily retrievable when needed.”*

SAS and Norwegian did good job on it. When searching for the booking and going to next steps, we can still see our search filters we searched for from the top. KLM did not do that. So Norwegian and SAS promoted recognition over recall but not KLM.

#### **4.4.7. Flexibility and efficiency of use**

According to Nielsen (1994) guidelines, this heuristic is defined as *“Shortcuts — hidden from novice users — may speed up the interaction for the expert user such that the design can cater to both inexperienced and experienced users. Allow users to tailor frequent actions”*

This is, according to us, not an applicable heuristic, as mobile applications don't really have those kinds of shortcuts due to less space and complexity of fitting everything in less space.

#### **4.4.8. Aesthetic and minimalist design**

This heuristic according Nielsen (1994) is defined as *“Interfaces should not contain information which is irrelevant or rarely needed. Every extra unit of information in an interface competes with the relevant units of information and diminishes their relative visibility.”*

Norwegian app looks a little bloated with too much information, but after a thorough look at it, all the information on it seems relevant, but not all of it is important

information.

SAS and KLM pass this criteria with KLM specifically having very pleasing and aesthetic design.

#### **4.4.9. Help users recognize, diagnose, and recover from errors**

According to Nielsen (1994) heuristics, this is defined as *“Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution.”*

Norwegian app is quite good at showing the errors in the correct place so that it is easy to point out the position where the error is.

On some forms, the SAS app does not have the good placement of errors. For Example, if there are two fields and both or one of them is not filled, then there was only one place where the error was being shown.

KLM almost prevented the error messages to be shown which is passing the criteria # 5 that is “Error prevention”.

#### **4.4.10. Help and documentation**

This heuristic according to Nielsen (1994) ten heuristics for user testing, this is defined as *“It’s best if the system doesn’t need any additional explanation. However, it may be necessary to provide documentation to help users understand how to complete their tasks.”*

This heuristic does not actually apply to SAS and KLM. They do not have help and documentation. However, Norwegian app has a help section which is pretty nice. On some help points, it actually solves the problem directly instead of telling the steps to follow.

## 5. Data analysis and guidelines with example mock ups

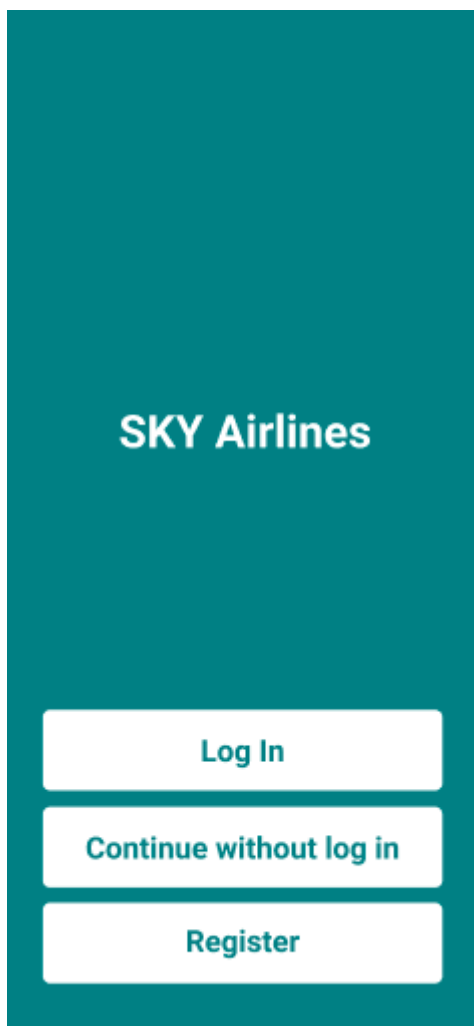
In this section we will go through all the test responses, heuristic testing, accessibility testing, automated accessibility testing results and try to figure out the common problems and how we can mitigate them. There are some problems we found out from different methods of collection but we will mention them only once here. We have taken inspiration from the apps we are testing plus the users' problems pointed out and the accessibility and usability tests result we have done and will make a prototype for each page or step before payment at least. We haven't included all the steps that today's applications have but the most important ones. So some guidelines are based on our data collection part but without mock ups.

Most of the problems stated by the users especially in the mobile app for the SAS is that the log in is the problem, they can't even search the flight without logging in. Users have expressed strong disappointment and frustration in this regard that even after resetting the password one of the users was struggling to log in and continue the search process.

The first guideline is

**1. Allow the users to continue the initial search process without being required to be logged in.**

Following is the example shown from our prototype for this guideline:



*Illustration 25: First page of airline application prototype*

So the users have the ability to login or continue without login and the first default step would be the search flight. They also have the option of registering a new profile on the app.

Coming to the search page, we tried to make it as simple as possible to let the users understand everything in our prototype. When the app is developed, there should be a proper label to each item so that the screen readers can easily read each item which is supposed to be read for the disabled users. The automatic testing accessibility scanner app which was based on "Google material design accessibility guidelines" also reported several issues regarding the items missing the label for

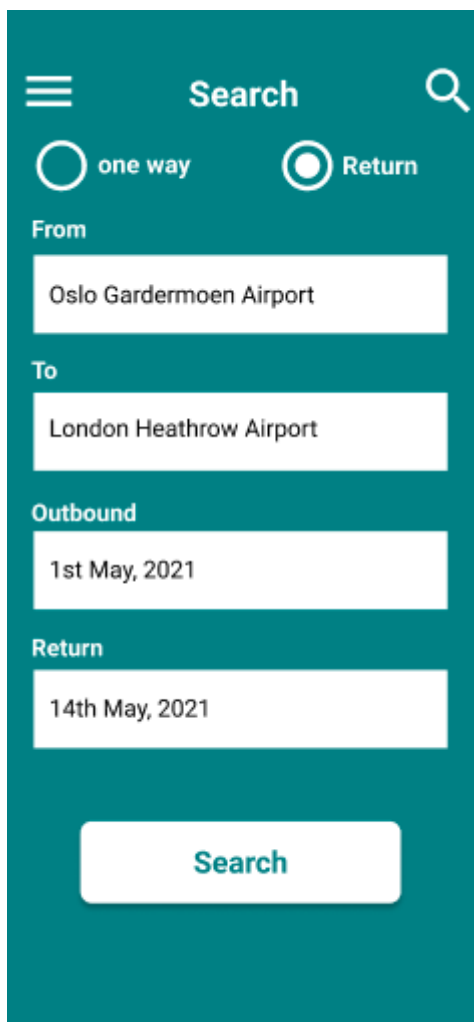
accessibility tools which is actually the verification of the same problem we found out during the manual accessibility testing. Hence, The second guideline is

**2. Make sure to give all the items a readable description for accessibility readers so that none of the important items are left out for the disabled users.**

Also according to google material design guidelines and WCAG 2.0 the text contrast for the larger text should be 4.5:1 and for the normal text should be at least 3:1. We made sure throughout our prototype and we have chosen the color scheme having the contrast of at least 4.5:1. This was the problem occurred when we manually tested the contrast which was also verified during the automatic accessibility testing through Scanner app.

**3. The normal text should have the color contrast of at least 3:1 and at least 4.5:1 for the larger text**

Following is the search page(illustration 26) having less information to be asked and easy to understand with the good contrast:



*Illustration 26: Search page of airline application prototype*

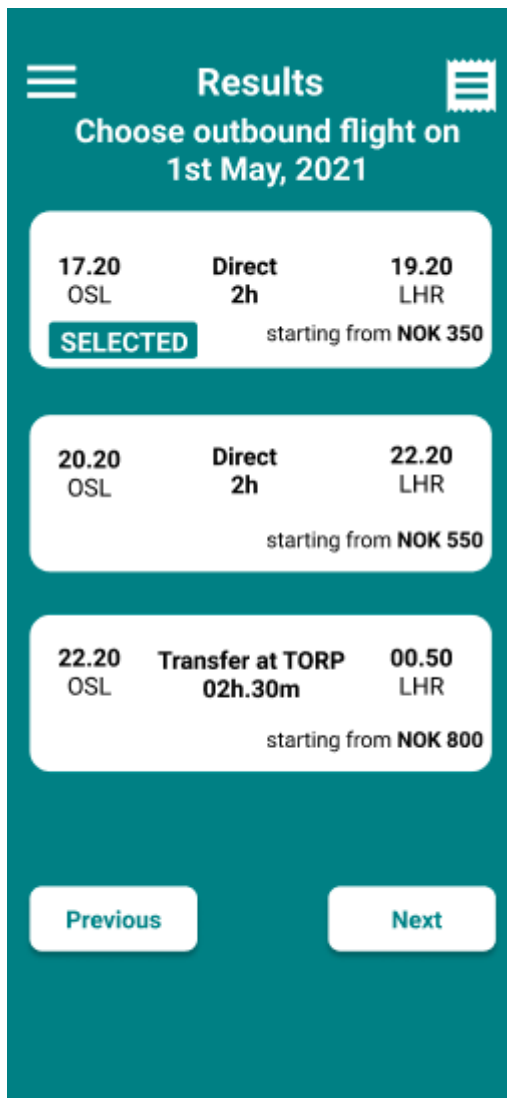
We tried to create the prototype based on only two colors, or maximum three which looks pleasing to the eyes.

Coming to the search result page, After analyzing users data which we gathered through google forms and through our own heuristics testing it has been observed that too much data in the search page is also a problem.

#### **4. Only the most important information should be displayed on the search results page.**

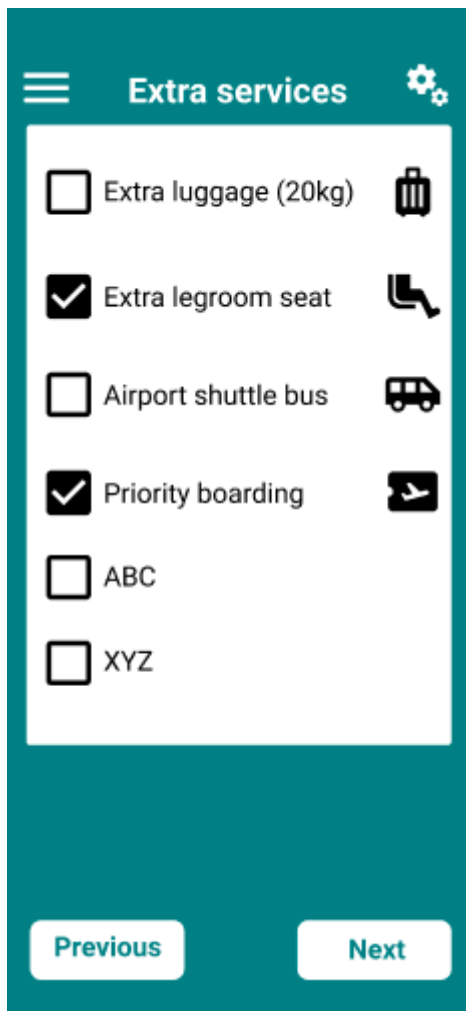
We have taken inspiration from KLM and have made our prototype search page like KLM but with little improvement i.e. bigger text as shown below, reasonable font size and text in good contrast which were the complaints from the users





*Illustration 27: Results page of airline application prototype*

After choosing the outbound and/or return flights the users normally have the option to choose the extra services to choose from. There should be less information on that page also to not confuse the users, for example as shown in following illustration 28:



*Illustration 28: Search page of airline application prototype*

Then after selecting the extra services and filling in the user details, the summary page is displayed normally where normally your trip summary is displayed which should not be polluted with so much information. After getting a lot of data from users and our own experiment we got to know that Norwegian and SAS do not show the summary page at all before payment of the ticket, KLM does show but it is not enough. It is missing the passenger information.

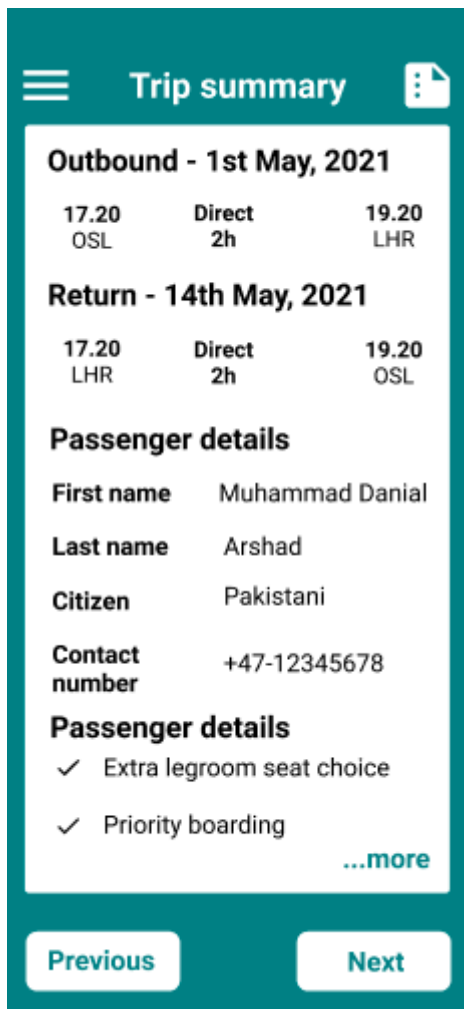
**5. There should be a summary page before payment in order to check all the information and selections are correct.**

The summary page should contain the most important information i.e. outbound,

return and passenger information with proper contrast and font size specially to mitigate the problem as one of our users stated.

**6. The summary page should contain the important information like outbound flight, return flight, optional services and the passenger information with good contrast of colors and good font size.**

The contrast should be such that so much text doesn't bleed into the eyes of the user having eyesight problems or similar. In our mock up we tried to make the summary page with best possible contrast and the most important information as shown below in illustration number 29:



*Illustration 29: Summary page of airline application prototype*

If we talk about the seat selection process, among the suggestions given by the user, we found one suggestion of showing the seats of different types with different colors which would make it easy to see beforehand which seat is of which type i.e. economy, business or first class etc. The scanner app also complained about the contrast there when the app shows the seats.

**7. The seats shown during seat selection process should be shown with different colors for different types and at the same time with correct contrast.**

Finding about the overall aesthetics of the apps we found different and interesting responses from the users including outdated design, too much information, improper use of icons and colors. In order to mitigate this problem we used mostly two and maximum three colors in our whole prototype with the best contrast and visibility.

**8. The color scheme for the app like this type with a lot of information should have fewer colors having correct contrast with proper icons showing the context of each item of information.**

When asked about improvements/suggestions from the users, we got many interesting and nice ones. Language option, difficulty to select the routes, additional summary page before payment, better previous/next navigation, improved app speed were asked for improvements in Norwegian. We have improved with respect to these things asked and put the better previous/next navigation button, mostly two colors with better contrast hence speed improvement, summary page before payment, easy access to language change option on our prototype.

**9. There should be clear next/previous navigation buttons along the process as not all the phone software provide clear/easy ways to do it, hence making it difficult for some users.**

Example of better navigation shown below in illustration 30:

**Passenger Details**

First name  
Muhammad Danial

Last name  
Arshad

Country of citizenship  
Pakistan

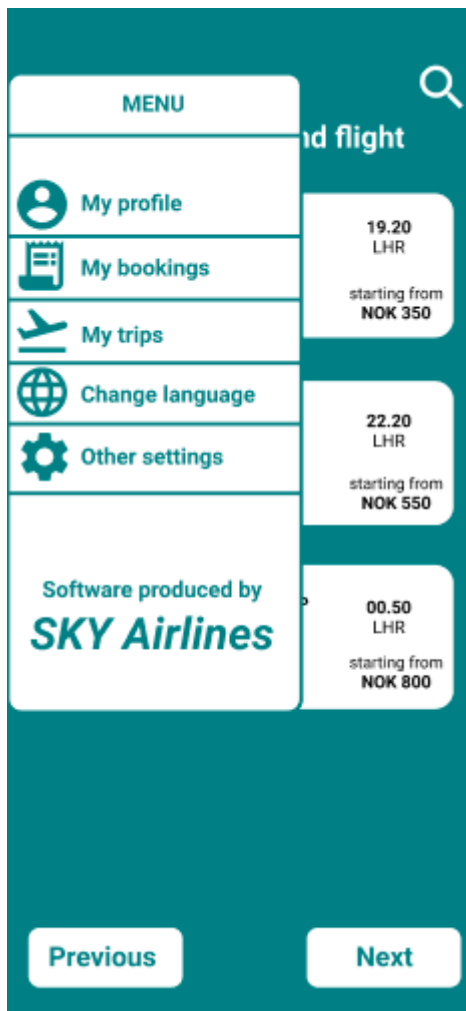
Mobile number (optional)  
+47-12345678

Previous Next

*Illustration 30: Passenger details form of airline application prototype*

**10. As per the nature of these kinds of applications, language option should be there and it should be easy to find as a user won't be able to find the language option if he doesn't know the language.**

This problem was mentioned by one of the respondents. As menu is the global feature every app has, so the user will try to find first in the menu by default as shown below in illustration number 31.



*Illustration 31: Menu of airline application prototype*

Separate field for return date, being able to search the flights without log in, same page departure and arrival city, modern design, and speed improvement were the things asked by the users when they tested the SAS app.

Same page departure and arrival city were asked by one of the respondents, no need to open the separate page for that purpose, this is not important and we are not including it as guideline but we have now in our prototype is the normal process which is both from and to cities selection are in the same page and separate field for return date also as shown below in illustration number 32:

The image shows a mobile application search form for flights. At the top, there is a search bar with a magnifying glass icon and a hamburger menu icon. Below the search bar, there are two radio buttons: 'one way' (unselected) and 'Return' (selected). The form is divided into sections: 'From' with the text 'Oslo Gardermoen Airport', 'To' with the text 'London Heathrow Airport', 'Outbound' with the date '1st May, 2021', and 'Return' which contains a calendar for May 2021. The calendar shows days from 1 to 29, with the 14th highlighted in a blue circle.

Search

one way  Return

From

Oslo Gardermoen Airport

To

London Heathrow Airport

Outbound

1st May, 2021

Return

May 2021						
MO	TU	WE	TH	FR	SA	SU
25	26	27	28	29	30	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

*Illustration 32: Design of choosing the return date while in search form in airline application prototype*



*Illustration 33: Search page of airline application prototype*

For KLM, the user complained that when dates were selected and the next form appeared, he/she had to put the country code for continuing which took a lot of time to realize and the complaint was about that it could be done in another place e.g. when registering user profile.

**11. There should be proper labeling about the mandatory fields or at least the optional ones so that users know which fields are must before pressing the next button.**

Example of proper labeling is shown below(illustration number 34) with one field as optional:

Passenger Details

First name  
Muhammad Danial

Last name  
Arshad

Country of citizenship  
Pakistan

Mobile number (optional)  
+47-12345678

Previous Next

*Illustration 34: Passenger details form of airline application prototype*

There are some WCAG 2.1 success criterias which failed and we found during Accessibility testing in section 5.2. One of the things was the layout missing in landscape mode.

**12. The app should be able to adjust its layout in landscape mode which means the layout should be responsive.**

There was another accessibility issue we found during the manual accessibility testing related to Timeouts which is level AAA success criteria basically was not applicable for the Norwegian and the SAS app but KLM was failing this. This means that there should be a warning of user data loss if the data is preserved for relatively longer time. So

**13. There should be warning of when the entered data will be lost if there is no activity for more than 20 hours. Important in these kind of data-intensive applications.**

While testing the navigation with external input tool such as keyboard, we found out that the apps are not fully navigable if used with secondary input mechanism which fails the WCAG 2.1 accessibility criteria 2.5.6 level AAA. So

**14. The applications should be fully navigable so the it can be used easily by secondary input mechanism and makes it easy for person who are not able to use the touch screens due to fat fingers or whatever problems.**

Coming to an accessibility problem found while automatic accessibility testing through Scanner app based on Google's Material design accessibility guidelines was about the size of Touch target. Some touchable items found by the scanner were small than the suggested ones.

**15. The touchable items should be at least 48dp x 48dp to make it. It is for the reliable interaction as per google's accessibility guidelines. This size is including the padding of the item.**

Related to another accessibility problem we found out during the automated testing is the redundant description of the different items. This might be wrongly caught by the app as it was noticed that the scanner app was finding this issue over the same item on different screens y considering it different items but this is a good point to note and take note of as it can cause confusion for the screen reader users when it is actually the problem.

**16. Each different item should have different description for screen readers to mitigate the confusion.**

One very important accessibility issue found out by the accessibility scanner app was that editable items having the content description which lets these items to be used same as other items and the screen readers speak the text inputted by the user

and treat them same as other speakable items. This leads us to guideline number 17 which is not only for airline applications but for all type of applications:

**17. Never give that description property to the editable item field which is given to other speakable items as this cause the screen readers to interact with that item's text which is inputted by the user.**

There were problems related non-text contrast found when doing manual accessibility testing which was also verified by the automated accessibility testing. According to WCAG 2.1 the contrast for the non-text items should be atleast 3:1 which was problem on lot of places. This is also a global accessibility problem and very common to find if development process is little advanced in this field. We will still include as guideline for these kind of apps as:

**18. Image or non-text contrast should be at least 3:1 to its background color to make it visible properly for all the users.**

After doing expert usability heuristic testing, we found out some more problems which should be put as a guidelines also. For example one of them was to show clear system status.

**19. The app should show the clear feedback or status what is happening in it, what are the errors, what functions has been done in a very clear, understandable and with the text having good contrast of colors.**

Related to another usability heuristics called "Error prevention" which is very useful but not very common for the apps to have, so

**20. There should be error prevention method rather than telling the users about the errors with the proper labels on each field as optional or mandatory fields, as these kind of apps require a lot of data to be asked from users normally.**

This means that if the user has a form to fill and there are lot of fields, first of all there should be proper labeling on the items that if it is mandatory field or not, and then don't the let the user to go to the next step before filling out the required information.

Related to another usability heuristics we found out a problem which was not followed by the KLM app here is the “Recognition rather than recall” which means that the app should not make the user feel that it has forgotten user’s searched data and the user has to remember it himself. Like the user search what he does in the first step here, if he wants to remind himself of the data or something he wants to change, he can go back and change. The guideline number 21 is

**21. The app should be able to provide a way to the user to go back any time and view or change their data.**

Then one of the most important usability problems is the language barrier in the apps. The language used in the app for error messages should be easy to understand, the placement of error message should be clear so that one knows what is the problem, where is the problem and how to solve it. There should not be one generic message in the long form as these kind of applications usually have, but there should be correct positioning of them, So copying the Nielsen Norman heuristics here we can say for airline applications that

**22. The error messages should be very easy to understand, be in good position showing the correct place for the error and it should say how it can be fixed. It saves user’s time which is an important usability aspect.**

The link to our prototype is

<https://www.figma.com/proto/RIST6ly5oJWWMYT9ke2RYG/airline-app-prototype?node-id=5%3A8&scaling=scale-down&page-id=0%3A1>

## 6. Discussion

It has been observed personally also that air travel is increasing. We have applied different methods to find the problems related to usability and accessibility of airline apps while choosing three airlines, two of them are the most flown airlines in Norway which are the SAS and the Norwegian, and the third one is one of most popular airlines in the world, the Dutch airline called "KLM". We have chosen mobile applications of these mentioned applications. We decided to do find problems using user testing through google forms, manual accessibility testing, automated usability testing and expert testing using Nielsen's Normann ten usability heuristics (Nielsen, J. April 24, 1994).

We did user testing google forms and not by physically meeting people and interviewing them due to some reasons. One of the reasons is due to living in the remote area where not many students are living as students are easier to target and request for this kind of testing. We had not thought about it earlier but then Covid-19 also started which could have been a reason but not as we didn't plan and know about it in the early stages of planning the thesis. Later on, when we actually started to get the user tests through Google forms, we came to know that we did a better decision as people don't have time to spend on it. We had to do many requests to get these only 34 responses we got. It went good and we found many interesting users' problems and we came to know how people think about the same thing. Diverse issues were reported, although some common ones among users also. No personal data was asked, everything was anonymous.

While the data collection from the users was continued, we also did accessibility testing using the mobile relevant guidelines of WCAG 2.1 and WCAG 2.0 by getting the unique criterias which were related to mobile applications. Several of the criterias which were not followed by these apps. Those are mentioned above in accessibility testing section.

We also did Automated accessibility testing through the Accessibility scanner app developed by Google called "Accessibility scanner" which followed the guidelines by

Google material design accessibility guidelines. The automated testing also verified couple of our issues we found during manual accessibility. The scanner app has found very useful issues which helped us a lot in making our mockups and making the guidelines.

We did expert testing our self and did not asked any other expert to do that for use for the obvious reasons discussed earlier in this section. We used Nielsen's (1994) ten usability heuristics to the expert testing. We found quite a few important usability issues by doing this like error prevention, system status etc.

The responses we got from the users were different from the manual and automated accessibility testing as the responses we got from the questionnaires are related to usability. The manual accessibility and automated accessibility testing results complemented each other, and the automated part verified some of the manual testing criterias also. All these methods helped us making our guidelines along with prototypes. It should be told here that we haven't created mock-ups for showing all the problems and guidelines made. The prototype was just to give the idea that how the interface should like showing the focus on color contrast, scheme of colors, font sizes, the importance of showing less information. The prototype shows how showing the most important information only, with good contrast eases the end-user usage and the user does not have to think about so many things and focus only on important information.

However, there could have been better methods used if we planned it better. For example, if we would have done some face-to-face interviews by requesting people and observing their reactions to different steps in the app might have given us more results. But this has not been done due to obvious reasons as in place of less population it's hard to find people to do this for us. But among other things we could have given it more time and we could have built the prototype showing each problem that we found and maybe even using more heuristics out there for doing expert testing. A better questionnaire could have been made by looking through any different types of guidelines and heuristics out there. For example, we got to know about the Google material design accessibility guidelines much later in the process

otherwise we could have make more use of it instead of just getting it's benefit through automated testing. But we managed to do good work around all the methods with limitations we had and produced some good outline of how things should have been done and if these things are thought about during the development process in the requirements gathering part, we can mitigate these kinds of problems.



## 7. Conclusion

After analyzing the apps through different approaches we did what our research question was stating as “*How can the airline booking applications be made better with respect to universal design so that they can be more usable to every kind of person?*”.

As a result we found problems in the airline mobile applications we mentioned which are Norwegian, SAS and KLM. After using different approaches like user testing, manual and automated accessibility testing and heuristics testing for usability it was good to note that nowadays the software companies do actually some effort to create better designs but we still found issues related to both usability and accessibility which can make these kind of apps even more better. After analyzing all the results we made some guidelines and a high fidelity prototype which has the most important steps included in it but not all the steps which a real application has now. That is because the prototype is helping towards only showing how our guidelines can help create a more usable and accessible apps.

The point to take here is that the development companies should take these considerations in the development life cycle as soon as possible to reduce their costs of making their product reach maximum people. If these things are worked on much earlier in the process they can reach more people in less time.

## **8. Limitations and future work**

The limitations regarding this document can be some formatting issues due to MS word not available to us. We have tried our best to make the formatting as correct as required from us.

Looking at the thesis work till now we have done, there is good scope which can be achieved further from here. More methods can be added in the same set of methods used here and the guidelines can be improved more. A full prototype can be made from here and the proper app can be developed which can be used as testing and validation of the guidelines which can help removing limitations from our work we have done here and then the end product can be used as an example for airline companies.

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# 10. Appendices

## 10.1 Survey/Questionnaire

We have chosen a set of questions which is mostly applicable and common to all three applications we have selected. Let us go through each question individually:

After asking the first question that which application will the participant test, we ask the user whether they have ever booked an airplane ticket before or not as:

1. *Have you ever booked an online airplane ticket?*

- Yes
- No

This question is asked so that we can compare and know how the users react with their first experience with using this kind of application and using the application. So that we know if the problems are due to the apps not being intuitive or due to some other reasons.

Furthermore, we ask them that which application are they testing from our three chosen airlines in following question:

2. *Which application are you testing?*

- Norwegian
- SAS (Scandinavian Airlines)
- KLM

It is important to ask this question as we will analyze and compare the apps on the basis of the app being tested. This sets a base.

Knowing which platform they are going to use the app on will be really helpful as sometimes the same app has some different functionalities on different platforms.

We ask this in following question:

3. *Which platform are you testing the app on?*

- Android
- iOS(iphone, ipad, Mac etc)
- Other

After this, we give the participant the task to book the ticket from “Oslo” to “London” as follows:

4. *Your task is to book a return ticket from "Oslo Airport" to "London Heathrow". (You don't need to book an actual ticket, just do the process before the payment) Tell us your experience about the search page where you started to search for the departure airport and destination. How easy was that page to use?*

- Very difficult
- Difficult
- Neither easy nor hard
- Easy
- Very easy

This question is the base of our survey, the first functionality to be tested and the main page normally participants will see. We are using the likert scale options in the above question and in other questions as well. Likert scale will make our result analyze easily. Likert scale does not force people to select a specific answer but provides a scale and they can choose the neutral answer if they want (Cleave, 2017, July 19).

Following the flow from the last question we ask the user to tell their experience about the search page results after searching for the flights in the question below which requests the answer in free text:

5. *In the search results page, is it easy to navigate through the different available*

*options of tickets ? How do you like the results page? Tell us about your experience in own words:*

Users can tell their experience freely in this question as each user can have different opinions on this and different ways of describing. This is one of the most important screens they will view after the first action i.e. searching.

In the next question we ask them their experience about filling in their information for booking and choose additional services in addition to the basic ticket as follows:

6. *How easy is it to fill in your required information and choose the optional services in addition to your ticket? For example, fast-track security check, extra baggage, travel insurance etc*

- Very difficult
- Difficult
- Neither easy nor hard
- Easy
- Very easy

This question is important as form filling is the one of the most important sections in the sense of users interacting directly to the app and trying to transfer their data into the app.

7. *Do you think all your ticket information like fast-track security check, extra baggage etc provided on the summary page are viewed easily ?*

- Yes
- No
- Not application (summary page not available on the app being tested)

The question above is asked to know how the app is showing the user filled

information back to the user in an easy way so that they can go through it and make/check any wrong information.

To follow up with the previous question's answer we asked the users why or why not the information shown was easy as follows:

8. *As part of the last question, why do you think it was not easy or easy to view information on the summary page?*

They can answer this question in free text.

As per the usual next step in this domain, the seat selection, we ask the users about the easiness of the seat selection process as follows:

9. *Do you think the seat selection process was easy to use ?*

- Yes
- No
- Not applicable (airline app being tested does not have this feature while booking)

Yes, No and Not applicable if the app being tested does not provide the seat selection. We have likert scales plus some open questions like these in our survey.

Then the follow up question to this is as follows:

10. *As part of the last question, why do you think the seat selection process was easy or not easy to use ?*

This gives the opportunity to provide the answer in free text also. The more we have open questions the more we can analyze the users deeper perspectives.

11. *How do you like the overall aesthetics(or design in simple words) of the application?*

This question is actually the wide open question where we ask generally about the whole app experience. This question is asked in order for participants to explain the overall aesthetics that the users have experienced and want to share them. It is also

good to ask a mixture of open and closed questions in order to have the quality results.

The last question is also an open question where we ask them if they want to suggest anything or have they occurred any other problem which they want to share with us as follows:

12. *Do you have any other suggestions/problems in the app you tested?*

Answers are requested in free text, for the same reason, to get the most deeper experience of users.