Making ATIS accessible for pilots who are deaf or hard of hearing

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INTRODUCTION

Deaf and Hard of Hearing (DHH) pilots can easily fly in an uncontrolled space, where radio use is not required to communicate with air traffic control (ATCO). However, DHH pilots generally cannot fly without any assistance in controlled airspace, where radio use is required. An important service for pilots in general aviation is ATIS (Automatic Terminal Information Service), a vocal message containing essential information, such as weather data, active runways, available approaches and any other information needed by pilots. Pilots usually listen to ATIS before contacting control, which reduces controller workload and decreases frequency occupancy. However, since this is an audio-based service it is currently not accessible to DHH pilots. D-ATIS (datalink) allows transmitting written information, but it is currently only used by large airports.

As a result, alternative communication methods between DHH pilots and air traffic controllers have been developed. Current communication methods that DHH pilots use are light gun signals, a tool used by ATCO to communicate with aircraft during communications malfunctions. These lights emit different colored beams and can be flashed or steady with different meanings for aircraft in flight or on the ground. A second method depends on a hearing copilot (radio copilot) onboard to communicate with ATCO (Major et al., 2018) or listen to ATIS, who then transmits the audio information to the flying pilot by writing on a whiteboard. These methods are not always possible in the controlled airspace of a large, crowded airport and thus present the primary barrier for DHH pilots in pursing an Airline Transport Pilot job or a non-commercial activity (Tinio, 2018).

The FANS4all association (Future Air Navigation System for All, https://fans4all.org/) aims at making it possible for DHH pilots to fly in controlled airspaces. One challenge is the accessibility of ATIS for DHH pilots. In this paper, we focus on the work conducted to make ATIS more accessible on the side of the user interface (i.e. the information presented to the DHH pilot).

RELATED WORK

Technology to support communication of DHH people (outside aeronautics)

DHH people are largely excluded from communication with hearing peers. In the area of Assistive Technology, many researchers have investigated how to support the communication of DHH users through technology. Deaf people largely rely on the use of sign language. One way to support this through technology is using sign language datasets (Bragg et al., 2021). An alternative is the generation of sign language avatars (Brock et al., 2020). Moreover, interactive systems allow presenting environmental sounds to DHH users through visual or tactile modalities often on mobile devices (Jain et al., 2020). For our work we conclude that the tactile sens can easily be used for alarms, but it is more convenient to provide detailed information (such as names, or numbers) using the visual modality as text or symbols. Moreover, mobile and wearable solutions have proven to be interesting for DHH users.

Making aeronautics more inclusive

In aeronautics, some studies have investigated the possibility of using technology to allow sensory impaired people to fly (Valéry et al., 2015). Blind pilots currently use a sonification system, the sound-flyer, which sonifies two dimensions of the aircraft attitude, i.e. pitch and bank angles. The sound-flyer sonification consists in modulating the features (i.e. frequency, rhythm, inter-aural balance) of a sinusoidal pure tone which is continuously displayed to the pilot via his headphones (Valéry et al., 2017). In contrast to these technological advances for blind pilots, no system is used for DHH pilots to the best of our knowledge. A promising avenue is the implementation of multimodal cockpit assistants (Lounis et al., 2019) or mobile assistants (Simon et al., 2022) to support pilots in difficult situations.

DESIGN PROCESS

To make ATIS accessible to DHH pilots, several aspects need to be addressed. In the current project, we focus on the user interface, i.e. how to display the information that is currently presented using audition with a different sensory modality. To design a system that meets the users' needs, in our case DHH pilots of General Aviation, we applied a user-centered design approach involving users at every stage of the design process to ensure satisfying their needs. This approach is in line with prior projects on mobile assistants for General Aviation pilots (Simon et al., 2022). Due to restrictions during the COVID crisis, we had to adapt the process to comply with the local instructions and some steps had to be conducted online. Since there are few DHH pilots in France (and none in Toulouse) we extended our user population to hearing pilots. 16 pilots (including 3 who were DHH) participated in our project. Our design process consisted in four different phases: exploration, ideation, elaboration and evaluation.

Exploration Phase

The goal of the exploration phase is to better understand the context and user needs. As a first step, a workshop with DHH pilots and designers allowed to better understand the current situation and problems of DHH pilots. Following this workshop, the objective of the project was defined as designing and developing an accessible ATIS system that 1) delivers the complete information currently delivered via radio / phone, 2) has a comparable or shorter acquisition time as ATIS via radio / phone, 3) has a comparable error rate as ATIS via radio / phone, 4) is usable during all flight phases, 5) notifies pilots about changes (update of ATIS) and 6) allows to select a new airport with a comparable or better time than ATIS via radio / phone. There was no constraint regarding the device to be used.

A second step consisted in an observation flight with two hearing pilots. Since the audio quality of ATIS was bad, we concluded that a written version of ATIS might even be of interest for hearing pilots. Third, we conducted interviews with 14 pilots (including one DHH pilot). This allowed us to prepare 17 scenarios which involved the use of ATIS and possible challenges, such as accessing the ATIS before the flight, accessing ATIS of an airport that was not initially on the flight plan during the flight, equipment malfunctioning, forgetting to consult ATIS before contacting ATCO, forgetting the frequency, etc.

Ideation Phase

The goal of the ideation phase is the creation of ideas based on the observations from the exploration phase. We conducted two brainstormings. First, an on-site brainstorming with 10 students from ENAC who were either studying to become pilots or aeronautical engineers, and second an on-line brainstorming with one DHH pilot and 6 pilot students. In both brainstorming sessions we asked the following two questions: 1) How should ATIS information be visualized ? and 2) How should ATIS be selected ?

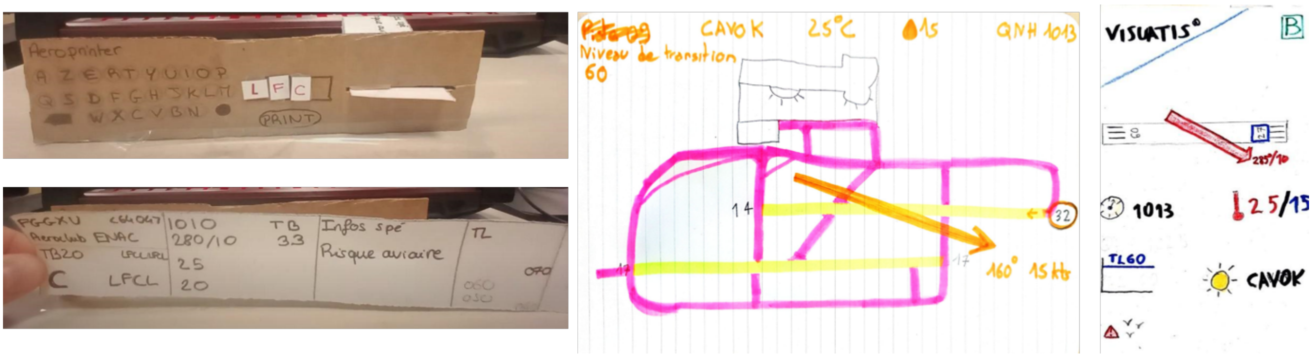

Figure 1: Examples of sketches from the brainstorming session from left to right: 1) strip-based interface, 2) sketch of the terrain, 3) mobile app interface.

At the end of the on-site brainstorming session, we asked participants to sketch ideas for an accessible ATIS system. Ideas for different types of devices were proposed, such as printing paper strips or using a mobile device (see Figure 1 for examples).

Elaboration Phase

During the elaboration phase, we followed an iterative design process, allowing us to converge from initial paper-based prototypes to a functional prototype on an Android tablet. Initially, we explored designs for four different device types: mobile phone, tablet, smartwatch and an embedded cockpit system. Videos of the prototypes were presented to ten users online and asynchronously. We analyzed and prioritized the collected feedback. Based on this feedback we made the following design decisions. First, we decided to focus on the design of an application for a tablet. Indeed, it presents the advantage over an embedded system that no modifications to the cockpit are required. Moreover, the display size is more adapted for visualizing ATIS information than the smaller size of phone or smartwatch. Finally, pilots are already used to carry on tablets while flying (Simon et al., 2022). Second, we learned that a radar view should be included. Finally, we noticed that a few symbols needed to be improved.

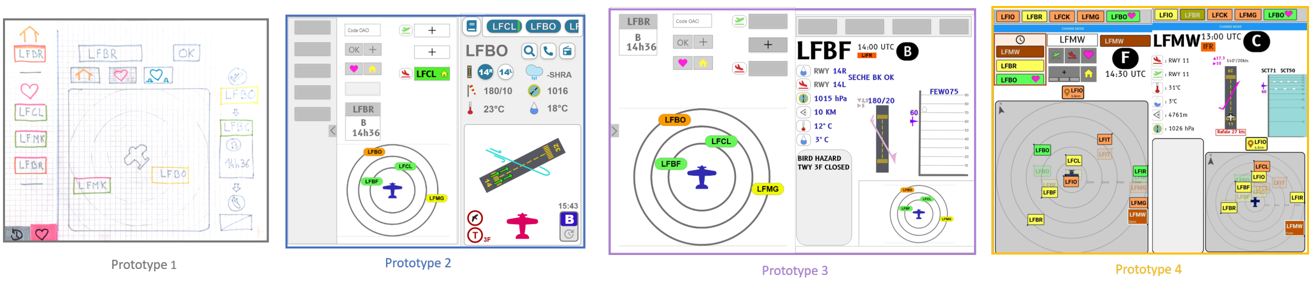

Figure 2: Iterations of the mobile app interface. Prototypes 2 to 4 are composed by two views: left: flight preparation, right: ATIS consultation.

Figure 2 shows the different iterations of the mobile app interface. Prototype 1 was presented on-site to four pilots in a TB20 simulator and to two pilots in a wooden cockpit simulator. Following the feedback from the users, modifications were made in Prototype 2 such as including automatic update of ATIS and displaying the version number through letters A,B,C,D etc.

Prototype 2 (Adobe XD) was presented to six users online in an experience map. This allowed to choose interaction techniques such as the pie menu for the radar view, a virtual keyboard with enlarged keys and gesture recognition for the input of OACI code as well as visual notifications.
Prototype 3 (Adobe XD) was presented online and asynchronous as videos to four pilots (including one DHH pilot). Feedback was collected through the use of a questionnaire. It allowed us to identify modifications that were considered in the final prototype for instance regarding choice of colors and symbols.
Prototype 4 was implemented in React Native on Samsung Galaxy Tabs S6 Lite with Android OS. It made use of the GPS position of the tablet and touch recognition. ATIS update was handled using HTTP communication. The interface was slightly redefined based on the user feedback in previous steps, but also due to constraints due to moving from and Adobe XD prototype to an Android implementation.

Pilot Study

We evaluated the prototype in a preliminary study with four pilots, including one DHH pilot. All pilots tested the application in a Flight Simulator with Microsoft Flight Simulator 2020 and then replied to a SUS questionnaire (Brooke, 1996). The three hearing pilots and an additional fourth pilot participated in a comparison between audio-based ATIS and our mobile app. We also collected qualitative feedback. DHH and hearing participants appreciated the application and considered it useful. The SUS scores were above 75 except for the first participant who encountered many technical problems during his test. According to Bangor et al. (2008), SUS values above 75 correspond to a good, respectively excellent usability. The comparison of audio-based ATIS and our application showed that the mobile app was quicker to use (mean gain of time: 13s). However, SUS and time scores would need to be verified with a larger number of participants. Qualitative feedback allowed us to identify aspects to further improve the application in the future. For instance, some symbols need to be improved to facilitate comprehension. Moreover, users requested to add direct interaction, such as touching and moving elements or zooming with pinch gestures. This is in line with interaction that is already used in mainstream tablet applications. However, direct manipulation might be difficult during turbulences and this would need to be studied further. Pilots also appreciated that the mobile app included features beyond ATIS (such as wind information and a radar view). It inspired them to aim even larger for a more holistic application that includes features beyond ATIS, similar as for instance FlyMate (Simon et al., 2022).

DISCUSSION

This project is a first step towards a more accessible ATIS developed through a user-centered design process with DHH and hearing pilots. However, the current project only addresses the user interface and some important challenges such as automatic speech recognition from radio-based ATIS still need to be addressed. Since, there are currently few DHH pilots in France (and none in Toulouse) this work has partially been conducted with sighted pilots. Beyond involving them as substitute users, we believe that an ATIS mobile app might be interesting for them as well since it allows including supplementary features and overcoming low audio-quality of ATIS.

CONCLUSION AND FUTURE WORK

In this paper we present the user-centered design, implementation and preliminary evaluation of an accessible tablet-based ATIS application. This project is part of a bigger project, involving Fans4All association, SII and researchers from Universities Rennes, Tarbes and ENAC, and we will continue the work on making piloting more accessible to DHH pilots. In the future, it would be interesting to conduct a controlled user-study with additional participants in a flight simulator or an aircraft. Moreover, it would be necessary to work on the certification and regulations to make this usable in the cockpit. We hope that this work will inspire other researchers and designers to work towards making aeronautics more accessible for people with impairments.

ACKNOWLEDGMENTS

First, we would like to thank all DHH and hearing pilots who participated in the project. We are grateful for the support by Fans4All association and SII. This project was also conducted during the M2IHM in Toulouse, and we would like to thank Sylvain Pauchet and Nicolas Saporito for their helpful feedback.

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