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## Multimodal communication device for light aviation pilots

### Dispositif multimodal de communication pour les pilotes en aviation légère

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In the context of light aviation, airborne communication between pilots and Air Traffic Control (ATC) is at present only ensured orally via a radio channel. To provide safer and more accessible communications and based on a FANS4ALL initiative, we are developing a multimodal Human-Machine Interface (HMI) combining the sight and touch. The device consists of a tablet placed close to the cockpit and a vibrating vest worn by the pilot. The goal is to enable pilots to stay informed, perceive new instructions and exchange feedback with ATC without a considerable increase in their mental workload or a degradation of their situational awareness that would degrade flight safety. Our application case is centered around deaf & hard of hearing pilots, with the collaboration of FANS4ALL members.

Dans le cadre de l'aviation légère, la communication aérienne entre pilotes et contrôleurs aériens (ATC) est assurée actuellement uniquement oralement via un canal radio. Pour garantir des communications plus sûres et accessibles et basé sur l'initiative de Fans4All, nous développons une Interface Humain-Machine (IHM) multimodale combinant vue et toucher. Le dispositif se compose d'un écran tactile placé à proximité du cockpit et d'une veste vibrante portée par le pilote. L'objectif est de permettre à un pilote de rester informé, de percevoir de nouvelles instructions et d'échanger des informations avec l'ATC sans augmentation considérable de sa charge mentale ni dégradation de sa conscience de la situation, ce qui nuirait à la sécurité du vol. Notre cas d'application est centré autour des pilotes sourds ou malentendant, une initiative de FANS4ALL et en collaboration avec ses membres.

Additional Key Words and Phrases: Multimodality, ATC communication, aeronautics, accessibility, auditory impairments

Mots Clés et Phrases Supplémentaires: Multimodalité, Communication ATC, aéronautique, accessibilité, déficiences auditives

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Fig. 1. Tablet interface placed close to the cockpit.

## 1 INTRODUCTION

When flying in Control zones (CTR), pilots must keep contact with Air Traffic Control (ATC). ATC assures diverse roles: guiding aircraft on the ground, issuing clearance, scheduling landings and take-offs, avoiding collisions, providing traffic information and weather information via the recording of the Automatic Terminal Information Service (ATIS).

Today, the only means of communication between general aviation pilots and ATC is the radio, thus making it an exclusively oral-based communication. This presents several limitations to both security and accessibility. Failure of radio or bad audio quality due to a multitude of external factors, can lead to difficulties understanding messages. Furthermore, oral communications exclude Hearing or Speaking Impaired (HSI) pilots from piloting autonomously in controlled airspace. Indeed, HSI pilots depend on a hearing pilot on board in charge of oral communications via radio with ATC, transmitting the necessary information to the pilot by writing on a whiteboard. These limitations highlight the need to explore a novel communication method between pilots and ATC which does not rely on audio. This solution could serve as a secondary backup for hearing pilots and a primary communication means for HSI pilots, enabling them to fly autonomously. In collaboration with the FANS4ALL association<sup>1</sup>, we developed a prototype addressing the distinct challenges encountered by HSI pilots during VFR flights.

## 2 METHOD

The prototype has been developed over several years in user-centered and iterative design cycles. HSI and hearing pilots, and air traffic controllers, have been involved during the design process. More details can be found in [1, 2].

## 3 MULTIMODAL HUMAN-MACHINE INTERFACE FOR PILOTS

To enable silent and secure communication between pilots and ATC, we developed a multimodal HMI that combines the senses of sight and touch. This device is composed of a tablet placed at the left end of the cockpit (Fig. 1), and a haptic vest worn by the pilot. The objective of the tablet is to enable the pilot to have a bidirectional communication with the ATC, without increasing their mental workload or diminishing situational awareness. Today, all messages received by the pilot's HMI are sent by a web-interface simulating the ATC.

<sup>1</sup>FANS4all initiated the project in 2017. FANS4all website : <https://fans4all.org/>

### 3.1 Incoming information : from ATC to pilots

3.1.1 *Messages from ATC.* The tablet application contains an ATC-pilot communication page on which received ATC messages are displayed via pictograms associated with plain text. This aims at facilitating and speeding up the pilots' reading and interpretation [2]. The pictograms' design is based on aeronautical phraseology and airport signage and has been iteratively designed with amateur and professional pilots. Simultaneously, upon receiving a message, pilots are alerted through various vibrational patterns sent to the haptic vest [2]. This is used to attract pilots' attention so that they do not have to continuously focus on the tablet, since their visual attention is also required for scanning instruments and the outside environment.

3.1.2 *ATIS.* The application also includes ATIS (pre-recorded ATC radio messages) [1]. The ATIS page is composed of three parts: (left) weather information (runway, temperature, dew point, visibility distance and pressure at sea level) represented by icons, (central) wind direction and intensity represented by vectors on the runway in use and, (right) clouds thickness represented for current altitude. The central panel contains the most relevant information.

### 3.2 Pilot outgoing information

3.2.1 *Flight setup.* On a first dedicated page, pilots complete the aircraft's information (matriculation, type, number of persons aboard). Subsequently, another page appears to plan the flight. The pilot will first select the type of flight (lap, local, navigation). Based on this choice, they are required to input information regarding their flight path, including the OACI code(s) of the airport(s), departure parking, exit and entry CTR point(s), and waypoints.

3.2.2 *Pre-filled messages for each flight phase.* The information from flight setup is used to generate pre-filled messages for the ATC-pilot communication. The aim of this is to reduce pilots' interaction with the tablet during the flight (i.e., not needing to type). These messages depend on the flight phases (rolling, take-off, cruise, etc.) and sub-phases (parking, waypoint, tailwind, etc.). The latter are automatically selected according to the incoming and outgoing messages, but, if necessary, pilots have the possibility to select them manually. In the cases where no pre-filled messages correspond to the situation, pilots have the possibility to write free text with a virtual keyboard.

3.2.3 *Emergency message.* Two emergency buttons, placed on the tablet header, are always accessible to the pilots. Pre-filled messages are sent to ATC according to the emergency selected by the pilots (fire, engine failure, etc.). Hence, pilots can react rapidly in case of emergency with not more than two touches.

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