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Power and Delay performance of Optical Wireless Communication inside Aircraft Cockpit

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Abstract/Résumé

This work investigates optical wireless links between four pilot headsets and access point inside aircraft cockpit for audio and physiological data transmission. We determine the performance of optical wireless channel along with DCF (Distributed Coordination Function) medium access control mechanism. The results show the trade-off between emitted optical power and communication delay.

1 Introduction

In the context of increasing bandwidth requirements, technologies are migrating to high frequencies such as millimeter and THz communications, but also optical wavelengths, which have the advantage of not being regulated. [1]. In addition, optical wireless communication (OWC) provides security, energy efficiency and high-speed rates. Depending on the use case, different OWC technologies can be used such as Visible Light Communications, Free-Space Optics, Li-Fi [1]. Standardization efforts on this technology are subject to different developments based on IEEE 802.15 (.7 or .13) and more recently 802.11bb.

As part of the Aircraft Light Communication (ALC) European project [2], the studied use-case involves the transmission of audio and pilot physiological data. We focus on bidirectional infrared communications between the pilots' headset and an access point in the cockpit taking into account pilot movements. Indeed, the brightness inside the cockpit must be greatly reduced during the critical phases of flight. Therefore, the visible band is not appropriate. In addition, the system should have an autonomy adapted to long-haul flights, typically 12 hours without any interruption. One of the main goal is to ensure global coverage, considering that significant changes in the settings due to pilot mobility can greatly affect the channel. To analyse this effect, we propose channel simulation results using a ray-tracing software developed at XLIM [3]. Moreover, the multi-user communication is based on 802.11 medium access control mechanism that is DCF (Distributed Coordination Function) algorithm with RTS/CTS (Request to Send /Clear to Send) method. In addition, to manage consumption constraints, we consider a power-efficient modulation scheme, which is PPM (Pulse Position Modulation). Our objective is to highlight the trade-off between emitted power and communication delay.

2 Results and discussions

The studied environment is a A350 cockpit as illustrated in Fig.1. Transmitters are located on the top of the headsets and on the AP at about 1m from the pilot's heads.

2.1 Channel simulation

We have developed a detailed 3D geometric model of the cockpit (see Fig.1) including the pilots' bodies and transceiver orientation and position changes resulting from movements. Consequently, the Line-Of-Sight (LOS) link condition cannot always be fulfilled. As a result, Non-LOS links evaluated by the ray-tracing software [3], contribute to the channel gain.

The channel analysis has been performed in term of optical gain determining the achievable SNR for a fixed transmitter power. As an example, we present in Table 1 the minimum DC gain values required to reach 100% reliability, considering a worst mobility scenario. The reflectivity coefficient of the environment is set to 0.5, the

half-power angle of the headset emitter is 60° , respectively 40° for the access point, the receiver Field of View is 60° and physical detection area is 7 mm^2 .

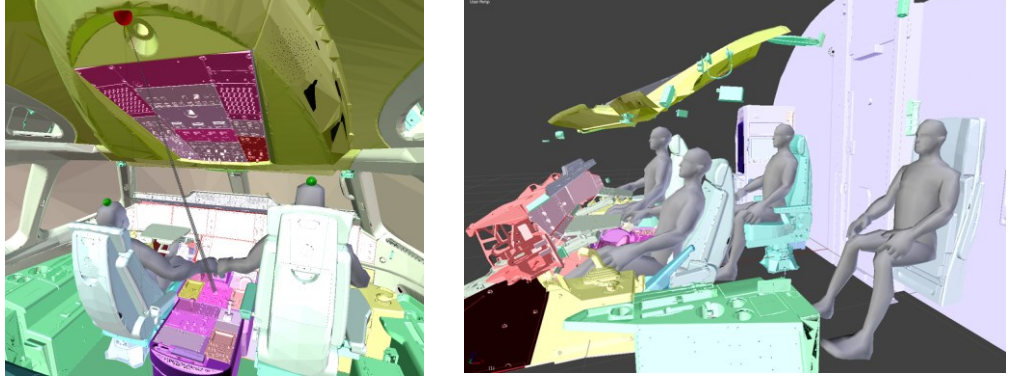


Figure 1: AIRBUS A350 cockpit and pilot position configuration

Table 1: Minimum DC gain Values (dB)

	Downlink	Uplink
Pilot	-69.7	-70.3
Co-pilot	-71.2	-72.1
Pilot rear	-68	-68
Co-pilot rear	-74	-72.2

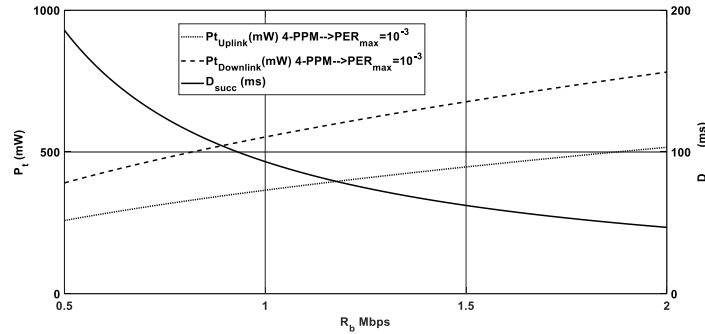


Figure 2: Emitted power and DCF delay versus data rate for uplink and downlink; co-pilot rear position, contention window = 63 slots, collision probability $p=0\%$

2.2 Delay and power analysis

Based on PHY and MAC analysis, optical emitted power and communication delay have been determined. They are plotted in Fig. 2 for PPM-4, a maximal size of MPDU (2500 bytes) and for a packet error rate $PER=10^{-3}$. As expected, the delay diminishes with the data rate, while the required power increases, highlighting the trade-off. Considering a maximal allowed power, we can deduce the optimal data rate to reach the minimal delay. Performance can be enhanced by increasing the spectral efficiency of PPM but at the cost of complexity. When a very low delay is required, adding diversity on the headset can be investigated as an alternative.

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