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Technical Note

The characteristics and control strategies of aircraft noise in China

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ABSTRACT

Aircraft noise pollution is a common challenge faced by the world. In China, this problem has drawn more and more attention from the local government and general public, as the average growth of aviation capacity exceeds 10% every year. Therefore this review paper aims to investigate the characteristics of China's aircraft noise, the underlying reasons for noise complaints, and the negative impacts of aircraft noise on human health. It is found that there is an increase, on average, of 3% hearing loss per exposure year in China. Aircraft noise can also bring potential damages to other physiological systems, such as the cardiovascular system. Along with the fast development of the aviation industry, complaints arising due to the disturbance of aircraft noise have occurred more frequently in China. For the residents living in the vicinity of the airport, aircraft noise can induce their annoyance at different levels, and it has been revealed that the areas and populations influenced by aircraft noise are predicted to grow steadily with the flight increase and airport expansion. Comparatively, Chinese residents might be more easily annoyed by aircraft noise. The differences among typical international aircraft noise standards and regulations, and the existing problems are also summarised. Finally this paper further explores the appropriate strategies for the reduction of aircraft noise, as well as the preventative legislation for the future.

1. Introduction

It is predicted that the demand for international air transportation will annually increase by 4.5–5% in the next 20 years [1], whereas China's annual growth of both passengers and aeroplanes has already exceeded 10% in the past 5 years [2]. The rapid development of China's civil aviation industry not only promotes convenience and prosperity to the airport-located cities, but also causes a series of environmental problems, especially the noise pollution.

Aircraft noise pollution has several common features with other types of noise pollution, such as sensibility, locality, and temporality [3]. It also has some distinctive features, for instance, higher sound pressure level and wider sonic influence ranges in dozens of square kilometres [4]. A number of studies have indicated that people affected by long-term aircraft noise exposure are very likely to be impaired in hearing [5–10] and other physiological capacities [11–17]. In addition, their mental states, working efficiencies, and reaction abilities are negatively influenced to various degrees [18–27].

If aircraft noise pollution cannot be effectively controlled, it will lead to serious deterioration of important relationships between airports and surrounding residents, and the sustainable development of the aviation industry [3,28,29]. From 2000, in being badly disturbed by aircraft noises, the relevant complaints and incidents occurred more frequently than before from the general public in China. Under this circumstance [30–36], the appropriate prevention and control of aircraft noise pollution have become extremely urgent.

Therefore, this paper aims to investigate the following questions: Firstly, what is the basic situation of China's aviation industry and airports? Secondly, in China, how does the aircraft noise affect human health? Thirdly, what are the actual measurements and predictions of airport noise in China? Lastly, based on the characteristics of China's aircraft noise, what kind of noise reduction and control strategies might be implemented? It is noted that, although a large number of cited reports and studies in this paper are written in Chinese, most of their abstracts are published in English.

2. Aviation industry development and relevant complaints

In recent years, China's aviation industry has boomed at a surprising speed [2]. As shown in Fig. 1, more than 10% annual growth of airport capacity was achieved at China's Airports from 2007 to

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2012, in terms of the number of flight departures and arrivals and the number of overall passengers. The CAAC (Civil Aviation Administration of China) further estimates that approximately 6–7 new airports are built each year in China, there being 148 airports in 2007 and 180 in 2012, and most of the airports are expanded and refurbished every 5–10 years, by building new runways or terminal buildings [2]. For example, as planned in the 4th phase of expansion of Chongqing Jiangbei Airport, the 3rd runway will be constructed by no later than the end of 2015.

Table 1 summarises the basic information about China's main airports. It is noted that some airports were built much earlier than the listed year of operation. For example, the old Shanghai Hongqiao Airport was initially built in 1907 as a small military airport. The majority of the Chinese Airports are connected to city centres via either light rail or metro, or this is under construction. At the moment, only Beijing Capital Airport and Shanghai Pudong Airport have 3 runways, and correspondingly, their runway operation modes are the most complex ones, in order to maximise the advantages of extra runways. An aircraft noise map is regulated as a compulsory document during the environmental assessment procedure in China, before the approval of any new airport or expansion projects. Moreover, a noise-monitoring device is claimed to be deployed at all the selected airports, but no such noise information can be found from the airports' websites. A notable noise problem is the large number of nocturnal departures and arrivals (11 p.m.–6 a.m.). For instance, there were 66 night flights at Beijing Capital Airport, as checked on a typical weekday. Compared to the relatively smaller airports, large airports often operate more night flights as expected, but there were few specific control strategies towards night flights at those airports. The only exception is Shanghai's two airports, carrying out the curfew restriction.

The Civil Aviation University of China [29] conducted a series of field surveys on the aircraft noise impacts of China's 121 airports in 1999 and its 148 airports in 2007, and the results are shown in Table 2. Their analysis indicated that with the fast development of the aviation industry, the aircraft noise pollution was rather significant, as the severely affected and relatively severely affected airports had accounted for nearly 15% in 1999, but this had risen by 4.1% from 1999 to 2007. However, the percentages of the slightly affected decreased from 70.2% to 62.8%.

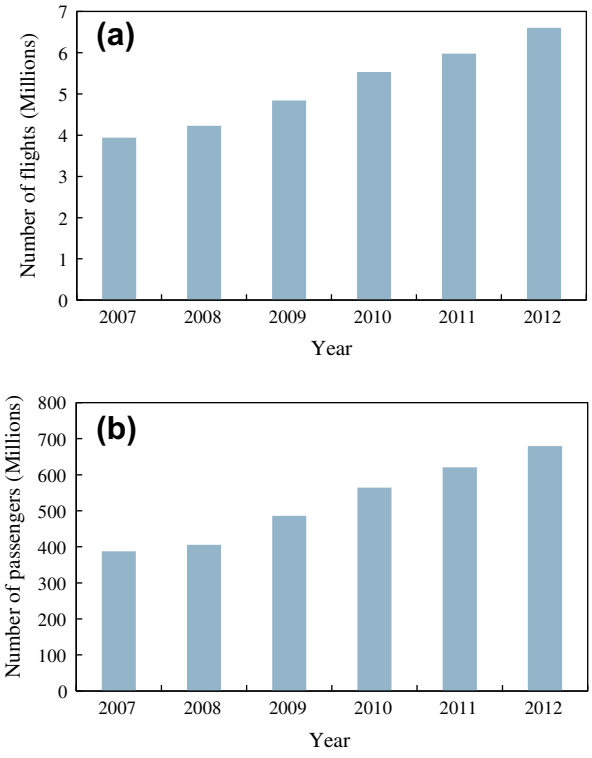

Fig. 1. The increasing capacity at the Chinese Airports from 2007 to 2012, (a) the number of flight departures and arrivals and (b) the number of passengers [2].

More complaints have emerged recently from the local residents due to the excessive aircraft noise [30–36], as provided in Table 3. It can be seen that the major reasons for complaints about aircraft noise were often induced by the increased number of flights, low flight altitude, presence of night flights, and inappropriate flight routes. This is consistent with two surveys conducted at Zurich Airport in 2001 and 2003, suggesting a linear relationship between the noise exposure caused by the increase of flights and runways, and the annoyance level of surrounding residents [37]. However, China's main problem is the lack of a sound legal system on aircraft noise prevention and control, which leads to a large number of complaints and disputes that cannot be solved effectively [4].

3. Impact of aircraft noise on the human health

The physiological and psychological effects of aircraft noise have always been the concerns of the public. Like many other countries, China launched various social investigations and collected a great amount of research data, as presented in Table 4. Wu's research [5] indicated that 46.1% of overall ground crew members at 5 airports were severely impaired by aircraft noises in terms of their high-frequency hearings. In detail, 32.7% of crew members with less than 5 years exposure, 47.3% of 5–9 years exposure, 54.4% of 10–14 years exposure and 67.3% of 15–20 years exposure were identified as having impairment of hearing. Apparently, their impairment was aggravated with the increase of their working years. Similarly, Li's study [6] proved that for ground crew who had worked for less than 5 years, only 14.3% experienced noise-induced hearing loss, whereas it rose to 50.0% and 82.9% for people with 6–9 years and over a decade of service, respectively. Huang et al. [7] discovered that during their investigation of 32 ground crew members, there were 0% (having had less than 5 years exposure), 12% (5–9 years), and 20% (10–19 years) of the staff with noise-induced hearing loss. Alarmingly, all the 3 members who had worked for more than 20 years had serious noise-induced hearing impairment. In addition, Zhao's survey [8] on 154 ground crew members at two air force airports indicated that the severely impaired members with high-frequency hearing loss accounted for 51.9% in total. Similarly, Gao et al. [9] stated that in their research the hearing impairment tended to increase along with the length of aircraft noise exposure on 873 airport-operating personnel, and their percentages of hearing impairment were 40.0% (with less than 5 years exposure), 47.4% (5–9 years), 57.3% (10–15 years), 54.8% (15–19 years), and 81.0% (over 20 years). Therefore, it is suggested that the closer to the noise sources and the longer the exposure years, the worse the hearing impairment would be. This is also in agreement with a noise study in Korea [10], where the prevalence rate of high-frequency hearing loss in all employees was 41.9%, and the incidences of noise-induced hearing loss were the highest in the groups of maintenance workers (65.2%) and firemen (55.0%), who are continuously exposed to aircraft noise. This indicates that the damages for the hearing of airport employees working closer to the noise source were likely to be more serious, as anticipated.

From the investigation conducted by Liu et al. [11] on one primary school located near the airport's main runway, it was revealed that the outdoor noise level L_{WECPN} (weighted equivalent continuous perceived noise level) of the students' learning