Continuous Descent Approach (CDA) compared to Regular Descent Procedures: Less Annoying?

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ABSTRACT

Annoyance reactions to different types of landing procedures were addressed in a controlled laboratory setting using a Virtual Community Noise Simulator (VCNS) with a head mounted display. Participants, standing on a virtual countryside road, experienced four types of descent flyovers by an A330 aircraft: a regular descent flyover at 2000ft and CDAs at respectively 3000, 4000 and 5000ft. These types of landing procedures are representative of flights approaching Amsterdam Airport Schiphol (AAS) in the Netherlands. Sound recordings for the VCNS were made on a countryside road and adjusted to match the indicated altitudes. After each flyover, participants were asked to rate their noise annoyance during the previous minute. Preliminary results showed that the 3000ft CDA was rated as the most annoying, followed by the ratings of the regular landing procedure and higher CDAs. These results could indicate that a CDA procedure, despite having lower LAmax and similar SEL levels, may still reach higher annoyance ratings due to longer flyover durations.

Keywords: Noise Annoyance, Continuous Descent Approach, Virtual Community Noise Simulator.

1. INTRODUCTION

At Schiphol Airport in Amsterdam, the Netherlands, two types of landing procedures are used: ‘regular landing procedures’ and Continuous Descent Approaches (CDAs). During a regular landing procedure the descent is stepwise, i.e. an alternation between descending and flying level at a fixed altitude (1). Extra engine thrust is needed to stay level at a fixed altitude, which causes increases in noise and fuel usage. Aircraft approaching the runway using the regular procedure fly level at 2000ft for about 15 kilometers, after which the final descent is made towards the runway for about 12 kilometers. A CDA is a procedure during which an aircraft glides towards the runway until about 2000ft and then adopts the regular procedure for the actual landing (also 12 kilometers)(1). All aircraft using CDAs are obliged to use the same route, which is not the case when using regular procedures (1,3). With a CDA procedure, less thrust is needed until the last 12 kilometers are reached, thereby causing less noise and saving fuel (2). Furthermore, the aircraft remain at higher altitudes for a longer time compared to the regular procedure. According to Clarke et al. (4), during a flight demonstration test at Louisville International Airports, the CDA resulted in significantly less acoustic energy and significantly lower fuel consumption.

If safety protocols allow it, since 2008 all night flights approaching Schiphol Airport have been using CDAs (1). On online fora inhabitants of villages close to Schiphol have questioned whether nighttime approaches are truly CDAs. This raises the question if CDAs are indeed less annoying than regular landing procedures.

We presented the noise in a Virtual Reality (VR) environment to allow for full experimental control, but with much higher immersion than is the case for regular lab experiments. It was hypothesized that

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people experiencing both regular and CDA procedures in a VR setting, would be less annoyed by the noise of CDAs.

When choosing the types of flyovers, the situation of approaching Schiphol Airport was held in mind. As most regular landing procedures are already at 2000ft when reaching land from over the North Sea, we used only one flyover sample of a regular procedure (which was at 2000ft). Annoyance ratings, measured with one question, of this sample were compared with three CDA flyovers at 3000ft, 4000ft and 5000ft respectively. Lower altitudes are not needed in this equation as they are equal to the regular landings. It was expected that the annoyance ratings for all three CDA samples would be lower than that for the regular landing procedure.

2. METHODS

2.1 Participants

Eight participants (6 males, mean age = 23.1, SD = 3.4) took part in this experiment at the moment of writing. They were recruited with an online registration website and rewarded with study credits or money (12 Euros). None of the participants reported any hearing problems.

2.2 Materials

The experiment was conducted in NLR's Virtual Community Noise Simulator (VCNS (5)) which is a copy of NASA's CNoTE system (6). The real-time audio rendering functionality of the simulator stems from AuSim's GoldServer (7). The GoldServer allows to apply, in real time, binaural effects to the audio based upon the real-time orientation of the participant in the simulator. The VCNS currently works with a Head-Mounted Display (eMagin Z800 3D visor) and head tracked headphones (Sennheiser EH250) The non-flat headphone frequency response was corrected, as far as possible, by preprocessing the applied audio signals. A piece of black cloth was used to block peripheral view next to the visor.

Four different sound samples of descending A330 aircraft were used: one regular descent procedure at 2000ft, and three CDAs at respectively 3000ft (from now on also called Low CDA), 4000ft (Medium CDA) and 5000ft (High CDA). The regular descent and the CDA at 4000ft were recorded in the province of Noord-Holland (near Castricum) in the Netherlands with a Bruel and Kjaer type 4189 microphone. The CDA samples at 3000ft and 5000ft were generated by shifting the flight path of the 4000ft flight by (+/-) 1000ft. Consequently, changes in spherical spreading and atmospheric absorption were applied to the recorded sample of the CDA at 4000ft. Applying signal processing tools (gain and FIR filters), the signals of the CDA at 3000ft and 5000ft were generated that reflect the change in propagation characteristics. No change in source noise was applied, i.e. all CDA descents contain the same noise geometry characteristics (directivity and Doppler shift) of the 4000ft CDA.

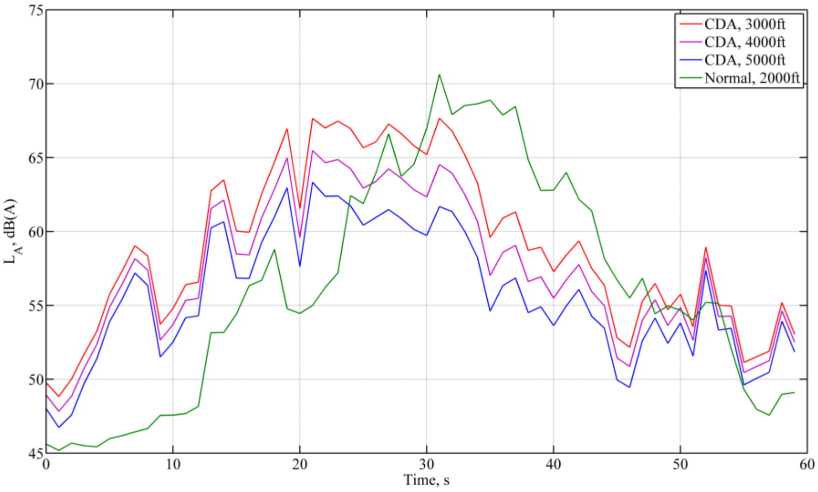

Figure 1 – Loudness curves of the four used flyover samples over time

In Figure 1 the loudness curves over time of all overflights are portrayed. SEL levels were 79.3 for the Regular Descent, 79.5 for the Low CDA, 77.1 for the Medium CDA and 75.2 for the High CDA.

The visuals in the VCNS showed a 360° photo of the site where the flyover recordings were made, portraying a countryside sand road next to a canal. Visuals of the flyovers were simulated by using OpenSceneGraph (OSG)[5] to render the virtual reality environment of both the scene (photo) and A330 flyover.

A questionnaire concerning demographics was used, which contained questions on age, gender, education, home environment and hearing proficiency.

2.3 Procedure

Participants started with reading an information folder and signing an informed consent form. After filling out a questionnaire on demographics, they were led into a sound insulated room where the headphones and HMD were adjusted to fit to the head. The experiment started after 90 seconds of exploring the virtual environment without noise. Every flyover was experienced twice, so eight flyovers were heard in total. Two different sequences were used to prevent order effects. After every flyover, participants were asked about their annoyance in Dutch with a question proposed by Fields et al. (8), slightly altered to fit the circumstances: ‘Thinking about the last minute, what number from zero to ten best shows how much you are bothered, disturbed, or annoyed by the aircraft noise you just heard?’.

After the experiment the participant was rewarded with money or study credits. The duration of the experiment was 30 minutes in total.

3. RESULTS

Figure 2 shows the means of the noise annoyance ratings for the sound samples. A mean effect was found for the differences between samples, $F(3,21) = 11.916$, $p < .001$, partial $\eta^2 = .630$. Unexpectedly, a simple contrast revealed the Low CDA to be more annoying than the Regular Descent, $F(1,7) = 21.000$, $p = .003$, partial $\eta^2 = .750$. No effects were found between the Regular Descent and the Medium and High CDAs, respectively $F(1,7) = 1.750$, $p = .227$, partial $\eta^2 = .200$ and $F(1,7) = 1.000$, $p = .351$, partial $\eta^2 = .125$. Furthermore, from pairwise comparisons it can be concluded that the Low CDA also resulted in more annoyance than the Medium CDA and High CDA, in both cases $p = .004$.

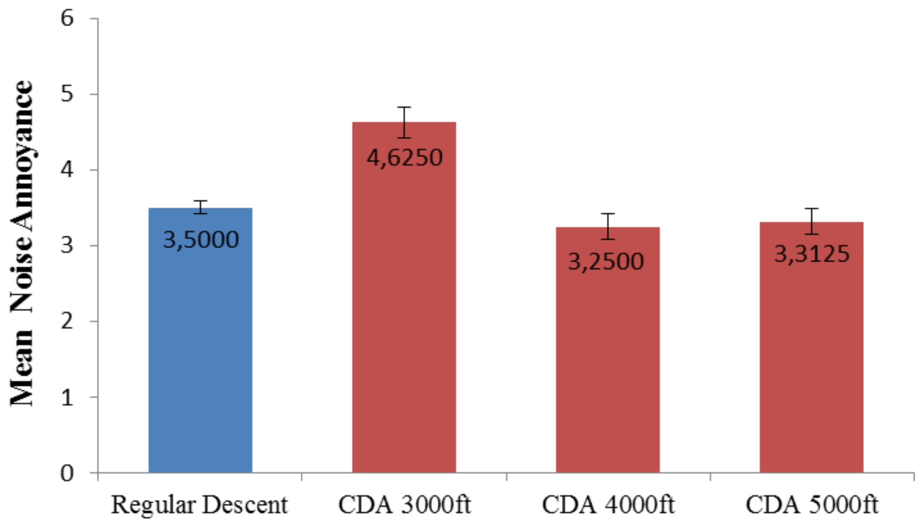

Figure 2 - Mean Noise Annoyance ratings for the four samples

[5] See, http://www.openscenegraph.org, visited 17-07-2014.

4. DISCUSSION AND CONCLUSIONS

Even though this experiment is still running as this paper is written, some interesting results have been found. Against expectations, the Low CDA at 3000ft was found to be more annoying than the regular descent procedure. Furthermore, the Low CDA appeared to be more annoying than the other two CDAs. No differences were found between the regular procedure and the Medium and High CDA.

An explanation for the regular descent not being more annoying could be the fact that, although LAmax of the CDAs are lower, the aircraft airspeed during a CDA flyovers is lower and flyover duration consequently longer. It seems as if being disturbed or distracted for a longer time could be more important than a few decibels difference. This could also be an explanation for the surprising lack of difference between the regular landing procedure and the medium and high CDAs.

It must be noted that the annoyance ratings in this experiment were not very high overall. At this point it cannot be ruled out that a) young adults just do not get very annoyed by aircraft noise and/or b) that participating in a VR experiment could be a nice experience resulting in less annoyance. A 90 second looking around interval was already put in place before the start of the experiment so any initial excitement could ware of, but there is no telling whether this was enough at this point.

Though it was not addressed in a systematic manner, participants did mention feeling rather immersed in the VR environment. Using VR technology could very well be a solution to lack of ecological validity in the laboratory on one hand, and lack of control in field situations. However, in a next experiment it would be a good idea to measure the immersion after completion.

If these results still hold when more people have been tested then the results could imply that because of longer flyover durations, CDAs could be causing more annoyance close to the airport than was previously thought. At this point, since there were no differences found between the regular landing and the medium and high CDA, it would seem preferable for noise abatement to not use CDAs since aircraft can use variable routes as opposed to only one when performing a CDA. However, although not yet significant, our initial data seem to suggest that at higher altitudes, so farther away from the airport, CDAs may cause less annoyance than regular landings. If this data pattern holds up with more power, the choice between regular and CDA landings would be one weighing annoyance close to the airport (potentially higher with CDA) against noise annoyance farther away from it (higher for regular landings). Other factors such as fuel consumption should also be taken into account. At this point more research is required before final implications can be made.

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