Evacuation simulations accounting for properties of the blended wing body aircraft

Yuming Dong*[1], Xiaolu Jia[2], Daichi Yanagisawa[1], and Katsuhiro Ninshinari[1]

[1]Department of Aeronautics and Astronautics, The University of Tokyo, Tokyo, Japan
[2]Beijing Key Laboratory of Traffic Engineering, Beijing University of Technology, Beijing, China

Abstract In this study, a blended wing body aircraft evacuation simulation model was developed to evaluate how the cabin layout can improve the evacuation efficiency of a blended wing body aircraft. Results demonstrate that an expanded aisle could be a simple method to evacuate a blended wing body aircraft in 90 seconds, while exit positions have limited influence.

Keywords Evacuation, Blended wing body, Cellular automaton, Stochastic processes, Simulation

Introduction

In an emergency landing, a fast and safe evacuation is the key to minimizing casualties. Currently, a full evacuation within 90 s is required by countries around the world for most passenger aircraft [1]. As a popular option for the next-generation passenger aircraft, the blended wing body (BWB) aircraft are anticipated to fulfill the ever-increasing requirements of good fuel economy and low emissions [2]. Previous studies on BWB aircraft evacuation often assume aisle widths and exit positions are similar to those of conventional aircraft. [3]. However, the BWB's large cabin is likely to provide more space for aisles, thus providing a viable option for improving evacuation efficiency and satisfy the 90-second rule.

Evacuation model

Live aircraft evacuation demonstrations are highly expensive and pose a significant risk to all participants. Consequently, computer-based evacuation simulations are indispensable for studying aircraft evacuations, especially for novel designs like the BWB aircraft. As shown in Figure 1, the evacuation model is based on the well-tested cellular automaton (CA) model. A 3D model of a BWB aircraft and the presumed cabin shape are also provided. This cabin poses a number of unique challenges for the emergency evacuation: larger cabin space, longer distance to exits, internal walls and supporting structures within the cabin, difficulty of placing emergency exits on the two sides, the higher likelihood of rear exit failures, etc.

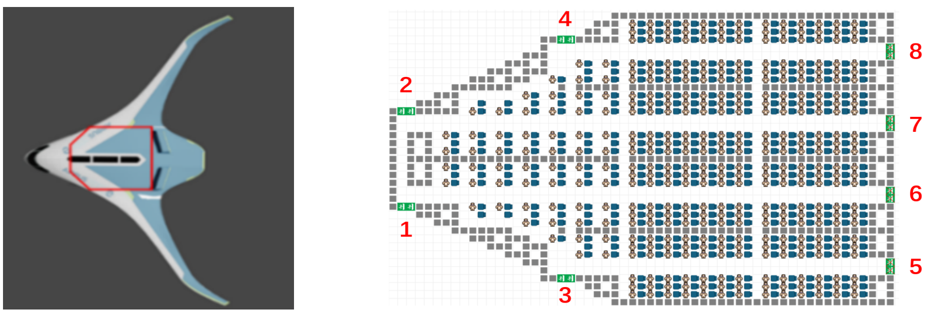

Figure 1: Left: 3D model of Airbus Maverick. The presumed cabin area is marked by a box.
Right: Overview of the evacuation model. It was designed to simulate a BWB cabin divided into four bays (mainly based on NASA's N2A-HWB), each with its own aisle. Exit 5, 6, 7, 8 are assumed to be unavailable to examine the worst-case scenario (longest distance to exits compared to other possibilities) for satisfying the 90-second rule.

*Email of the corresponding author: dong-yuming@g.ecc.u-tokyo.ac.jp

Once the simulation starts, 370 agents will mark the closest exit as their target and begin moving. If an agent cannot move forward because of congestion, it will attempt to randomly change target if possible. The total time required for all agents to leave the aircraft is recorded as the evacuation time. Considering the uncertainty in the cabin design of BWB, a number of cabin layouts were tested to find out how the following four factors can influence the evacuation efficiency: 1. The widths of four aisles: the BWB cabin may allow aisles wide enough for two agents; 2. The locations of exits: moving exit 3 and 4 further towards the tail; 3. The widths of exits: increasing the width of exit 3 and 4; 4. Areas near exits: how much space do exit 3 and 4 have, and the number of obstacles near exit 3 and 4.

Results and discussion

As shown in Figure 2, only aisle widths have a significant impact on the evacuation. All four aisles must be at least two cells wide to bring evacuation time below 90 seconds. The cabin should also allow small open areas near exit 3 and 4 to ensure a fast evacuation. Locations and widths of exit 3 and 4 have limited influence on the evacuation time. Considering that adding extra side doors could be a significant challenge for the BWB aircraft designer and manufacturer, increasing the aisle widths could be relatively straightforward and effective method to comply with the 90-second rule. Adjustments in supporting structures may also be necessary to create open areas near the exits. This indicates that no significant alteration is required for many existing BWB conceptual designs. For example, placing the cabin below the wing in order to create more side doors may not be necessary. Further study may include additional factors such as stress responses and passengers with disabilities.

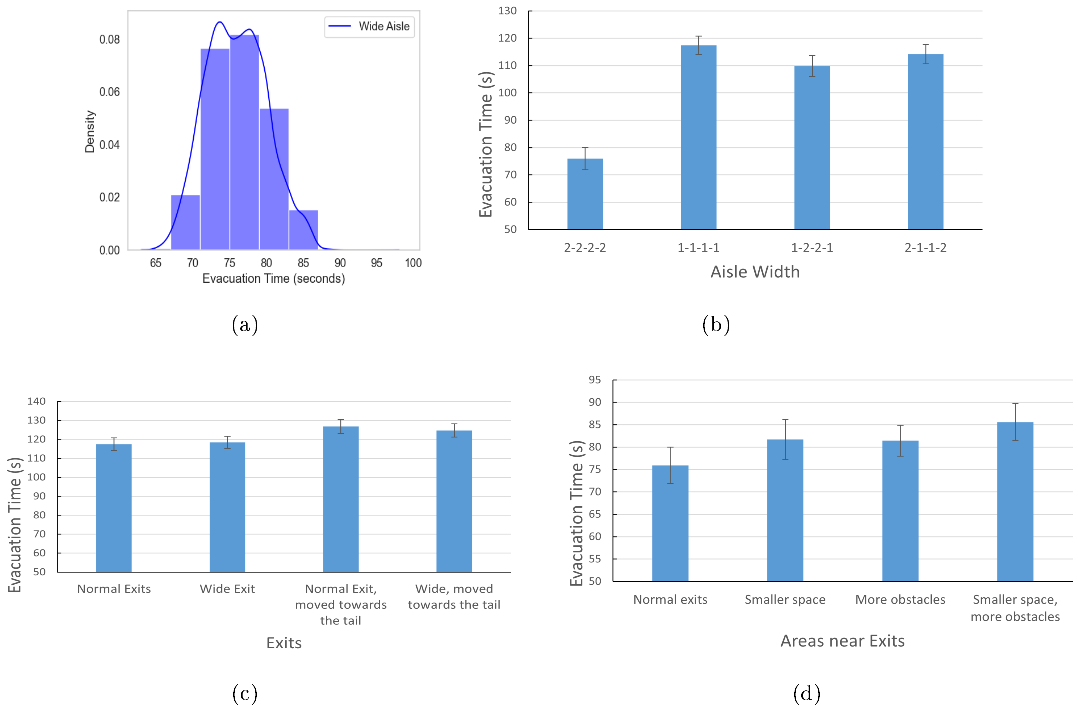

Figure 2: (a): Kernel density distributions of the evacuation time when all aisles are two cells wide.
(b): Evacuation time when widths of four aisles are different. The four numbers refer to aisle widths from left to right. For example, "1-2-2-1" means the two inner aisles are two cells wide, and the outer two aisles are one cell wide.
(c): Evacuation time when locations and exit 3 and 4 are different. All aisles are one cell wide.
(d): Evacuation time when areas near exit 3 and 4 are adjusted. All aisles are two cells wide.

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