Pedestrian Flow Simulation and Capacity Analysis of Stations and Pods of Ultra-High-Speed Ground Transportation (Hyperloop)

Master‘s Thesis of Hsuan-Ting Wu

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Research Motivation

Ultra-high-speed ground transportation, also known as hyperloop, is a new transportation concept that applies the technology of magnetic levitation and low-pressure tubes to run at a higher speed but a lower cost than other alternative transportation modes. The hyperloop system requires corresponding stations to provide passengers with suitable boarding and alighting facilities. While there have been many papers looking into passenger simulation, bottlenecks, and level of service (LOS) in the existing stations and terminals, similar analyses for hyperloop systems are rare. Therefore, this study aims to explore the passenger flow and LOS of hyperloop stations in different station designs during the peak hour and to identify the potential bottlenecks in these conceptual hyperloop stations. Through passenger flow simulation and comparisons of different station layouts, the most appropriate hyperloop station configuration was recommended based on the average travel time of passengers and the percentage of time spent by passengers in low LOS.

Methodology

First, based on concepts in the literature and current hyperloop technology, several assumptions were made in advance as many features about hyperloop systems remained unknown. After confirming all assumed parameters, a simple two-floor hyperloop station was constructed in PTV Vissim for passenger flow simulation. During the simulation, some abnormal congestions may occur due to the uncertainty of pedestrian behavior and the complex interaction between simulated objects. Therefore, systematic refinements were implemented during the first few simulation runs to adjust the model inputs. Next, potential bottlenecks were identified according to the LOS defined in this study. Colormaps of passenger walking speed and experienced density were produced to better understand the bottleneck hotspots. Afterwards, this study proposed five additional station design layouts to improve the passenger flow. Furthermore, a sensitivity analysis was performed to observe the relationship between passenger demand and passenger-related outputs. Fig. 1 shows the workflow mentioned above.

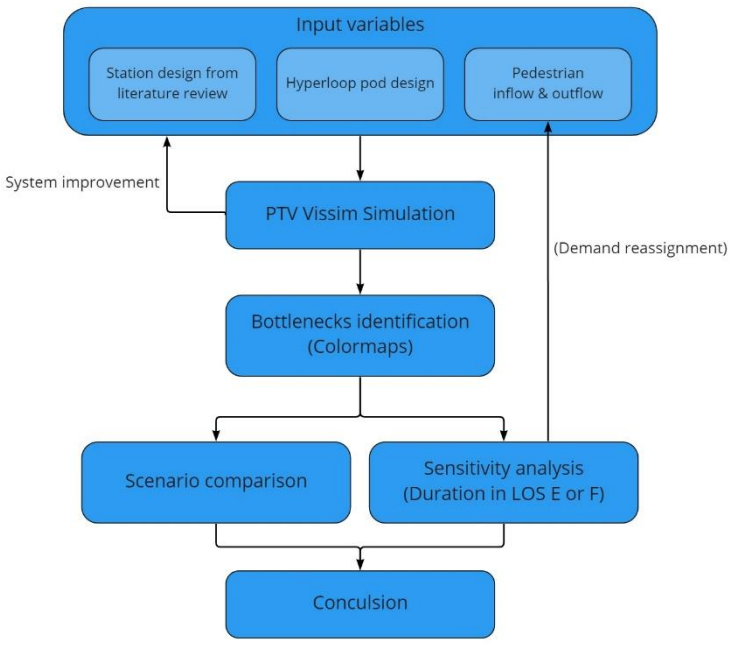

Fig. 1 Study workflow for passenger simulation

Simulation Result

Figs. 2 and 3 show the performance of two attributes in the Vissim model to identify potential bottlenecks in the basic scenario.

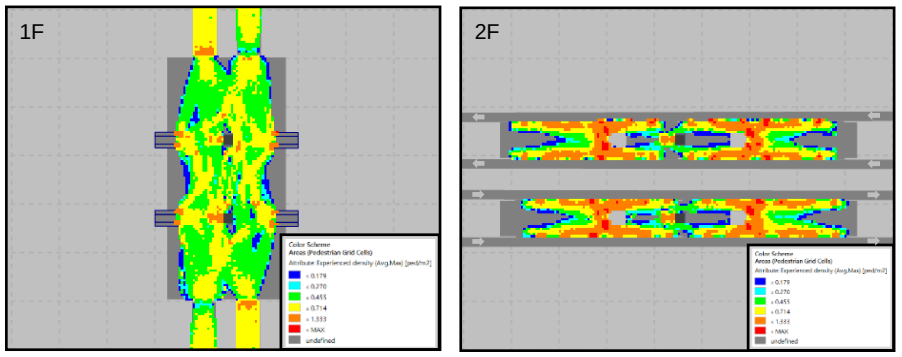

Fig. 2 Colormap of maximum experienced density

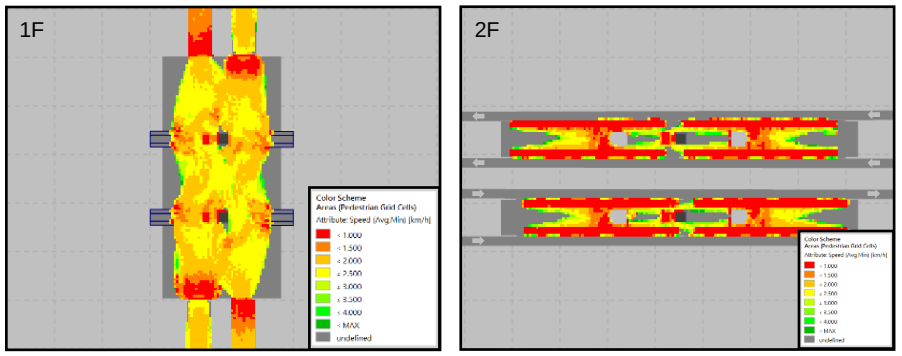

Fig. 3 Colormap of minimum passenger walking speed

Conclusion

This study designed several possible hyperloop station layouts to analyze the passenger flow conditions and compared these scenarios to find suitable station layouts to avoid bottlenecks and congestion. It could be observed that the entrances and exits of ticket gates and vertical transportation were the potential bottlenecks for each proposed station configuration in this study. Besides, if there was a serious passenger flow conflict, congestion was also prone to occur near the boarding gate on the platform. Therefore, this paper employed two main indicators to evaluate the performance of each station scenario. The scenario of platform function separation, which equipped with three boarding platforms and two alighting platforms, had advantages in both evaluation indicators. With further development through validation and calibration, the analytical process presented in this study could become an effective tool for hyperloop researchers and relevant authorities to assess passenger flow conditions and detect potential bottlenecks in future hyperloop stations.

References

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