Vision: prosocial interaction in future vestibule space

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ABSTRACT
Most vestibules in trains are labelled as unpleasant environments for commuter travel due to their lively nature and impracticality of spatial solutions. Consequently, the current use case for train entrances leaves room for relabelling and improvement. As its main objective, this study aims to create an efficient collective space, that manages find tools for converting unattractiveness into positive travel experiences that support prosocial behaviour among the passengers. Results in this study show that material choices applied to public spaces can be used to evoke desirable emotions in an audience. Furthermore, solutions in spatial planning can serve as triggers for active interaction between train travelers. This study is envisioned to benefit in particular an audience that appreciates active ways of spending travel time and seeks to benefit from mutual interaction possibilities during their journey, such as young students.

Authors Keywords
Vestibule, collective transport, social interaction, travel satisfaction, spatial efficiency.

1 - INTRODUCTION
An individual train trip in the Netherlands lasts on average 36 minutes, and approximately 50 % of all journeys are less than 30 minutes in length [9]. Instead of using their time usefully (e.g. conducting work), passengers set higher preference for spending time pleasantly (experiencing positive stimulants) [9]. Meanwhile, a train vestibule is seen as the least desirable compartment of a train interior, even if the travel time is short [11]. This leads to the following assumption made by the design team: enhancing positive travel experiences, especially in vestibule areas, could be an impactful way of contributing to general travel satisfaction on trains.

According to NS (Dutch Railways), young travellers (under 25) such as students, are more likely to stay in vestibules compared to other traveller types. The company's reasoning is that an open space like the entrance attracts passengers that appreciate greater freedom for movement and interaction within a group. Consequently, the research question for this study has been formulated as: "How to create an active vestibule space, particularly for students under 25, that supports free movement and creates opportunities for passenger interaction?

A number of past studies show that railway companies such as the NS are increasingly showing interest towards addressing the customer experience and accounting for the full door-to-door journey while improving their service quality [11, 5, 6, 7, 8]. Additionally, a number of research initiatives have studied the concept of comfort in public transport and factors influencing it [1, 14, 4]. Instead of only analysing the theoretical background for travel satisfaction, few studies have chosen a more practical approach into conducting research on train travel. This study aims to differentiate itself by providing a concrete redesign proposal for a public transport space, and not only basing its choices on academic research but also generating new knowledge through practical design actions (research through design) [13].

In greater context, this study aims to bring a contribution towards designing purposeful, well functioning spaces in collective transport. As such, it should provide interventions that make an already easy train journey also into a pleasant one by meeting conscious and subconscious needs of its target group.

This study has largely taken place in the premises of Eindhoven University of Technology, where purpose-made research sites simulated the actual proportions and dimensions of an NS train vestibule. Participants in the study consisted of university students under 25 years old. Furthermore, observation through field trips in a real-world environment, as well as expert interviews have been a fundamental part of the process.

This paper is structured as follows: chapter 2 gives a comprehensive overview of literature used by the team.

Next, in chapter 3 follows a description on the various design methods used to conduct this study, including corresponding findings. Chapter 4 discusses implications and limitations of the study. Finally, chapters 5 and 6 conclude the paper by recommending future work and summarising the findings.

2 - RELATED WORK

It is not uncommon for a material texture to evoke certain feelings or associations in its observer. Naturally, this also applies to materials found in public spaces, such as on seats, tables, handles etc. A study by Ebe and Umemuro [3] has studied the relationship between texture and emotion, which indeed concludes that emotional information can be translated via material textures. In the context of pleasant and comfortable interiors, it is wort mentioning that the most happy emotions were conveyed by warm and soft textures [3]. Furthermore, Melcer and Isbister [12] claim that emotions are translated also via visual dimensions of an object, adding another aspect to the research. This study has aimed to describe so-called affective shape dimensions, observing for example that sharp and rounded edges represent negative and positive valence, respectively [12].

Train travel, just like all collective transport, involves a strong social link: whether we prefer it or not, a space is most often shared with a group of people. To investigate the effects of social interaction in public spaces, Holy-Hasted and Bruchell [10] have studied how individual well-being can be derived from the properties of a public space. The study observed that so-called hard spaces (e.g. city squares in urban areas) were associated with well-being. In particular, Holy-Hasted and Bruchell state that hard spaces "are potentially associated with well-being due to their ability to cluster people together in an intimate space, fostering opportunities for passive and active social interaction." [10, p. 9]. This result should however be interpreted with caution when applying it to closed places in public transport. In a separate study, Damen et al. [2] describe that the rushed environment of public transport easily leads to a lack of positive attitudes or actions among people. The paper aims to establish a link between prosocial behaviour (enhancement of welfare of others) and positive empathy towards the surrounding travellers, suggesting that inducing positive mood increases prosocial actions [2].

In a paper by Allinc et al. [1], comfort in public transport is being explained by a set of parametres. Traditionally, comfort is linked with ergonomics, and factors such as vibration, sizing, etc. However, this study takes a psychological dimension, where Allinc et al. describe comfort as "an enjoyable pleasant and relaxed psychological state felt by a person who is interacting with its surroundings." [1, p. 1]. Factors used to determine this are the feeling of safety, control of own social space, and time control, among others [1]. General attractiveness of public transport, i.e. travel satisfaction, is dependent on a greater scale of variables, according to a research study by Sukhov et al. [14]. Alongside psychological and ergonomic comfort, the aspect of cost, as well as functionality (travel times, ease of travel etc.), were seen as inevitable quality aspects for high level of travel satisfaction [14]. Additionally, a study by van Hagen to NS [5] describes a train journey predominantly as a service, where the train serves as a form of 'packaging' in the customer experience. The paper specifies that out of a full door-to-door trip, the train journey itself has the greatest impact on travel satisfaction. Notable is that interior design aspects contribute to the experience positively only if the service process (punctuality, staff etc.) is successful first [5].

A 2020 paper by van Hagen et al. [8] claims that interior design interventions are relatively cost-effective ways of tackling passenger comfort in trains, when compared with functional aspects of running train services. Perhaps surprisingly, a questionnaire analysis also revealed that passengers set higher priority for a pleasant train interior than punctuality of the schedule [8]. Furthermore, an article by van der Made and van Hagen [11] describes the core needs of NS customers: being in control of the journey, feeling appreciated and welcome, and being free to spend time one's own way [11].

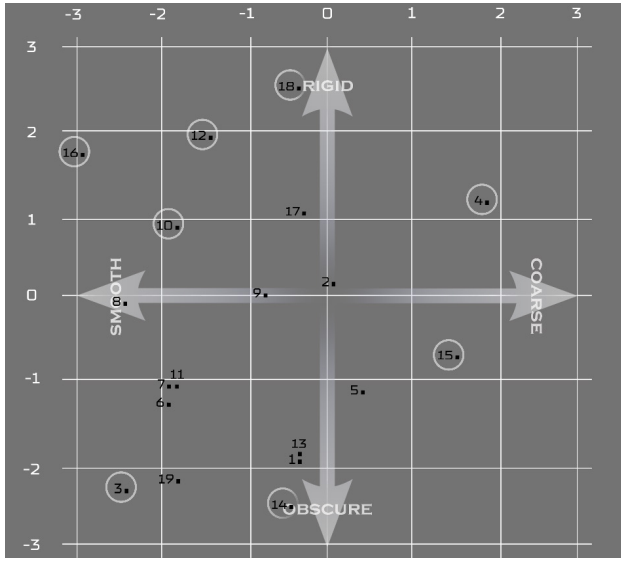

Figure 1: material mapping.

3 - METHODOLOGY

Material insights: test 1

The primary phase in the research process focused on soft material considerations. The eventual goal was to gain insights into possible links between tactile material properties and evoked emotions in test participants. The study included 19 soft material samples (1 removed out of original 20), with a wide range of different surface textures.

Initially, all materials were to be mapped on a 2-dimensional axis system, with both axes representing a tactile property variable, see figure 1. The choice of the two variables, coarseness and rigidity, was in part contributed by related literature (Ebe and Umemuro [3]), and in part by first person perspective intuition: the mapping should be able to accurately convey material behaviour and texture. Here, coarseness stands for the roughness of the material surface, and its opposite could be described as smooth. Rigidity refers to the firmness of a material, and its opposite can be seen as flexible.

User testing took place in a setting where 16 participants were asked to quantitatively rate each material sample, on a 7-point Likert-scale for the said tactile variables. The participants were encouraged to stroke, rub and squeeze the materials. To avoid any interference by visual properties, the sampless were placed in a closed box (see figure 2), thus not visible to the participants.

Material insights: test 2

Following the results from preceding mapping, 8 material samples (2 samples from the extremes of each quarter) were selected for the next phase. Instead of tactile variables, the team was now interested in the feelings and emotions that the chosen materials would evoke.

A mixed qualitative/quantitative questionnaire was created, where 9 participants were asked to rank the samples with respect to 5 different emotions, on a 7-point Likert-scale. The choice of emotions was based on research conducted by Ebe and Umemuro [3], and represented both the so-called basic emotions and prosocial emotions: sympathy, confidence, happiness, satisfaction and predictability. Participants were also asked to describe their experience and feelings in a few words. Visual interference was again avoided with a closed-box-setup.

Findings

The first user test resulted in a mapping which shows a small bias towards smooth rather than coarse materials, which meant that the upcoming second phase was also affected by a slightly uneven distribution. For the results, refer to figure 1.

Analysing results from the second phase, a number of conclusions could be made. Firstly, the team identified samples with the greatest and lowest amount of positive associations. The emotion of sympathy was in this case linked with the most positively perceived material. In contrary, the emotions of hostility, dissatisfaction, and surprise, were linked to the least positively perceived material (for visualisation, see figure 3).

Connecting results from test 2 with test 1, the team was now also able to identify the most positively perceived materials (nr. 3 & 14) on the axis system: it was clear that a positively associated material correlated with smoothness, obscurity, or both. In other words, smoothness has a positive impact on predictability, gratitude and confidence. The more rigid material, the less happiness is conveyed.

Expert interview

After gaining understanding over applicable material types, the team wanted to direct their focus on the greater interior context of trains. To assist with this, the team contacted NS for a discussion on the company's design strategy. The interview also presented an opportunity to inquire what particular issues NS was currently trying to tackle in regard to train interiors. The discussion was held with Ms. Brigitte Matheussen, lead architect for NS asset strategy, and Mr. Mark van Hagen, principal consultant.

The team gained a great amount of crucial information on the NS design approach, but also about specific material requirements that often are linked to national and international transportation regulations. According to NS, identifying the target customer and their specific needs was an important first step to be taken. After a customer experience mapping has laid out the customer's journey, it is possible to translate this information into an envisioned interior. In a real-world setting, a variety of limitations on material aspects, technical, as well as financial aspects dominate the design process. Feasibility of a design must account for durability, cleanability, vandalism, fire resistance and adaptability/flexibility, among many others.

When asked about current challenges, Mr. van Hagen noted that train vestibules are in a particular need of improvement: present day train entrances are inefficient with space use, chaotic and unpleasant for spending time. NS envisions this space to be best suited for a young, active audience.

The discussion aided the team in specifying a clear target for the later design phases, and laid out feasibility requirements for a realistic research study.

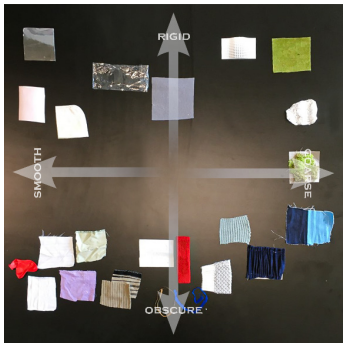

Figure 2: user test 1.

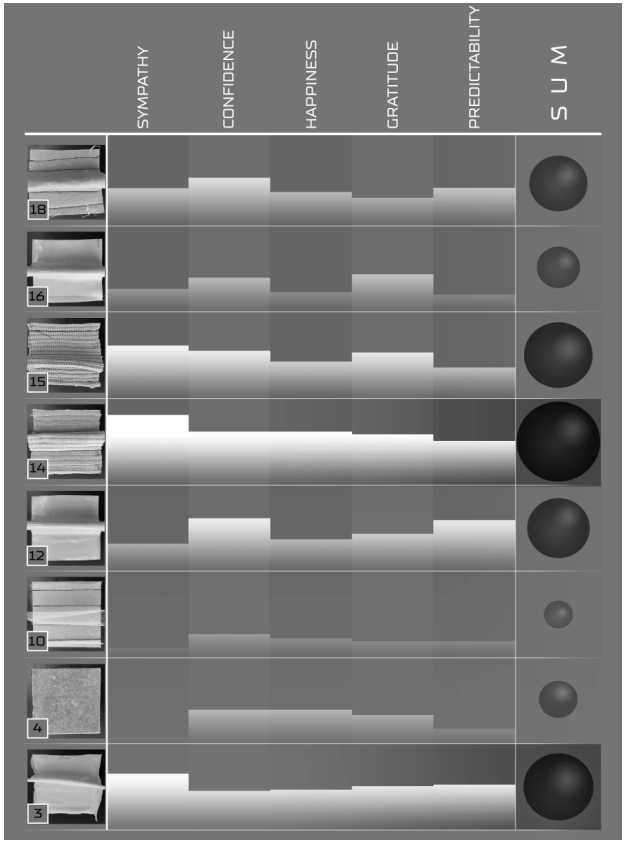

Figure 3: Results, mixed method study.

Field trip

Observing the real-world public transport environment was a way to gain better understanding over the actual design space. The team made field trips in order to observe interaction between passengers and their movement in multiple means of transport, including trams, metros, and trains (see figure 4).

Another objective for the field trip was to select a specific train type (NS intercity VIRM), and a specific vestibule onboard in order to create an accurate ground plan of the space, see figure 5 (for an additional ground plan please refer to appendix A).

Space organisation: inventory

At this stage a preliminary inventory was made, meaning that with the help of chosen requirements and known user needs, the team was able to fix a set of necessary equipment in the vestibule space. As per the original train layout, the new space should provide (seating) capacity in minimum for 8 passengers. Additional space should be left for at least one workstation/table. Further initial considerations were a preference for leaning posts instead of conventional seats, ease of movement, storage possibilities for bicycles, unobstructed window views, and unobstructed aisle path.

To best understand the 1:1 scale proportions of the chosen vestibule space, the ground plan was recreated by taping it on the ground. The team studied possibilities for movement of passengers and potential equipment layouts for upcoming iterations, see figure 6. As a result of this exercise, 9 different layout suggestions were created.

Space organisation: test 3

Third user test had the objective of assessing the quality and practicality of the suggested ground plan layouts, including various equipment types. In addition to a vestibule-mimicking limited space with ground plan taped on the floor, the test also made use of 1:1 sized cardboard mock-ups of the imagined interior objects.

This test was attended by 13 students, divided in groups of 2-4 participants to simulate a realistic situation with an intended amount of occupants per vestibule section. For all layouts, insights were gained on e.g. practicality of movement and limitations to personal space. In addition, participants were encouraged to share any additional thoughts that the process evoked (see figure 7).

Findings

The test environment clearly demonstrated obvious impracticalities of certain interior layouts. This meant that options such as circular tables or window-facing workstations had to be discarded. In addition, participants shared their personal preferences for train

Figure 4: field trip.

travel, mentioning details such as preferring not to have direct eyesight with unknown co-passengers. Most passengers preferred to be positioned in a way that provided a complete overview of the surrounding space. Furthermore, some indicated the preference for leaning against a wall (if standing), thus increasing the feeling of safety and comfort. Lastly, popularly suggested additions to the space were power outlets, grab handles, and supports to lean on.

Eventually the study resulted in choosing one ground plan layout that best managed to account for the spatial requirements and user needs. Ground plan for this selection can be found in Appendix A, consisting of a set of leaning posts, space dividing elements, and tables. It is worth noting that apart from a schematic top-view mapping, the exact dimensions of leaning posts as well as workstations were still to be determined in upcoming steps

Final layout: leaning posts

The main feature in the redesign proposal is a set of leaning posts, replacing conventional seating in the vestibule space. As a result of an upright standing position, the leaning post suggests for, and assists passengers in active ways of (group) interaction. Furthermore, it does not enforce passengers into spending travel time passively, by choosing a regular seat. It is expected that such a layout choice will attract passengers that prefer active travel (young students under 25), meanwhile also freeing up sought-after seating capacity in actual seating compartments.

Two leaning post types have been applied. Leaning post #1 consists of a slender rectangular main element, with a slanted cross-section and a leaning angle of approximately 40-45 degrees. One end of the main element is complemented by a triangular end-piece that allows space-efficient corner positioning, and additionally provides support against lateral movement of the train. For illustrations, see figure 8.

Leaning post #2 comes in two shape variations. The first variation, with two distinct leaning directions, has a secondary function as a space-dividing element that

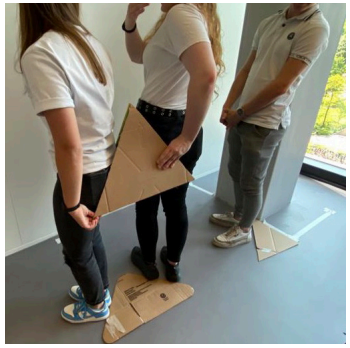

Figure 7: user test 3

Figure 5: chosen vestibule in an NS intercity VIRM- train.

Figure 6: spatial planning exercise.

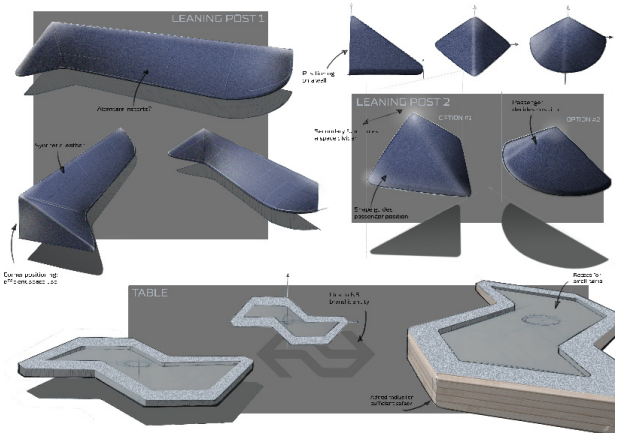

Figure 8: illustrations - leaning posts and table.

splits one side of the isle into two ‘clusters’. This could be seen as a benefit for the adaptability of the space. The second variation with a conical shape may still act as a subtle space divider, but does not limit the leaning direction into two options only. Leaning post #2 is placed on a transparent wall that is suspended from the ceiling, leaving the lower half open. This ‘floating’ wall secures the back of leaning passengers and separates the space from the main aisle, while a removed lower section keeps the overall space open and less limited for wheelchair access and bicycle storage.

Final layout: table

Fitting a table into a highly compact space should only be done to increase the functionality and potential of the space, not to limit it. A table/workstation was seen as a medium to enhance interaction possibilities between passengers, very much similar to the function of a bar table or an exhibition-fair stand.

Similarly to leaning post #2, the table may also separate a space between two or more strangers, creating a feeling of privacy. During user testing, the chosen shape was considered as space efficient. A resemblance to the NS corporate logo is a link to the company’s brand identity.

For the benefit of accessibility and adjustability, the table is suspended from the ceiling with a hydraulic aluminium strut. Structural feasibility is ensured by industry-grade componentry and mountings directly into the train chassis, similarly to hydraulic main door frames.

Prototyping: leaning post #1

Considering limited resources of the team, instead of a full interior mock-up, the team decided to accurately prototype one element in full size: leaning post #1. Starting with a wooden frame structure, overall dimensions and proportions were fixed (see figure 9).

Previous research conducted on material influence on comfort and travel satisfaction suggested that the element should be soft. This choice is also a benefit for safety considerations in a moving vehicle. The frame was filled with shape-cut, fire-retarding polyurethane foam, after which the 3-dimensional foam shape was further secured and formed by a flexible net-fabric (figure 9).

Surface material choice was heavily affected by current industry standards and requirements on aspects such as durability and vandalism resistance. The team therefore chose to upholster the leaning post with synthetic leather, commonly used in today’s public transport due to its exceptional properties. For initial measurements, the object was covered with woven cotton fabric that would later be cut into templates for the surface material. Eventually, using the templates the synthetic leather was cut and carefully sown together. Finally, a stapler was used to fix the material in place. For the prototype, see figure 10, and for additional spatial illustrations, see Appendix A.

4 - DISCUSSION

The first two user studies have given the team useful insights, especially as some results also matched previously made research [3]: soft materials conveyed more positive emotions, whereas more rigid materials conveyed more negative emotions. However, a limitation of these studies was the fact that the chosen material samples were not material types commonly

Figure 9: Leaning post construction.

used in public transport, or materials that would as such be applicable for the purpose. Nevertheless, the eventual results were helpful for the final material choice. In addition to these insights, also requirements provided by NS were considered.

In the overall process, despite attempting to account for a comprehensive amount of regulations, this proved to be a difficult task. Therefore compromises were done and the applied solutions may not be in line with the rules set by all regulatory bodies. In some cases, instead of abiding to strict regulations, the team used keywords provided by NS as a guidance, such as adaptability/ flexibility, cleanability etc.

Initial planning during the project included the manufacturing of additional prototypes, such as a second leaning post, as well as the table. The construction process took however much longer than initially expected, resulting in one prototype only.

A physical, realistically scaled leaning post did provide the team with useful insights, e.g. in the form of user feedback (informal context). Additionally, the model was able to demonstrate the materials used and give an indication of how to interact with the object in a real-life situation. A drawback was that this prototype could not be tested in a formal setting.

Looking back at the research question, it is possible to argue that the team managed to create a final layout that promotes the properties of an active vestibule space. Nevertheless, further research and testing, if successful, could considerably strengthen this claim.

5 - FUTURE WORK

The findings of this study have been conducted in a simulated environment, which poses its limitations to the validity of certain results. Furthermore, user studies were conducted in groups that were relatively small: a small sample size is prone to biases. Lastly, due to limitations in resources and time, an actual full-size prototype space could not yet be constructed.

Considering future work possibilities, testing of the chosen layout in a realistic environment would be an important next step to validate some of the assumptions made, and to iterate the concept further. Despite the team's best efforts in attempting to design a space with well functioning equipment (leaning posts and tables), the concept could benefit from multiple additional considerations. Firstly, new soft material possibilities for the surface material could be applied so that the choice is better in line with observations made with research. Next, the optimal positioning of the leaning posts needs further studies, assessing also whether height adjustability would be a feasible addition. Additionally, the concept of tables requires reconsideration. In current layout, tables have a purposeful function, however, more has to be done in order to account for safety concerns, structural integrity, and practicality in a realistic setting. Lastly, interaction between passengers requires further studies, including tests between friends, as well as strangers.

6 - CONCLUSION

This study has re-imagined the use-case for commuter train vestibules. Generally seen as unpleasant and inefficient environments, the design team has in consultation with NS proposed a new way of using train entrance spaces. This envisioned vestibule is directed to an audience that appreciates active ways of spending travel time and seeks for mutual interaction possibilities, resulting in increased usability and travel satisfaction.

The contributions of this study range from materials insights to spatial design in the context of collective environments. Firstly, studies on material properties suggest that a link between tactile material properties and evoked emotions may exist. This increases our understanding of material choices when designing spaces for comfort and positivity. Secondly, the study has proposed ways of converting passive public environments into spaces that support prosocial behaviour. Additionally, suggested improvements in ground plan have improved the spatial efficiency of current (NS) train vestibules.

Figure 10: Leaning post prototype.

The study has primarily been a knowledge-generating exercise on mobile social spaces. Mass transit of urban centres is subject to a wide range of requirements and expectations by its users, as well as strict regulations by governing bodies. National railway systems, like the Dutch Railways, provide a platform that is highly characteristic for these merging demands and thus continue to be a compelling target for future design interventions.

7 - ACKNOWLEDGEMENTS

We would like to thank Rong-Hao Liang for coaching us throughout this semester. Furthermore, we thank all experts within the squad for helping the team throughout the project steps. Equally, we appreciate the valuable input of the study participants, as well as their insightful feedback. Lastly, we send our thanks to Brigitte Matheussen (NS) and Mark van Hagen (NS) for sharing their valuable knowledge with us.

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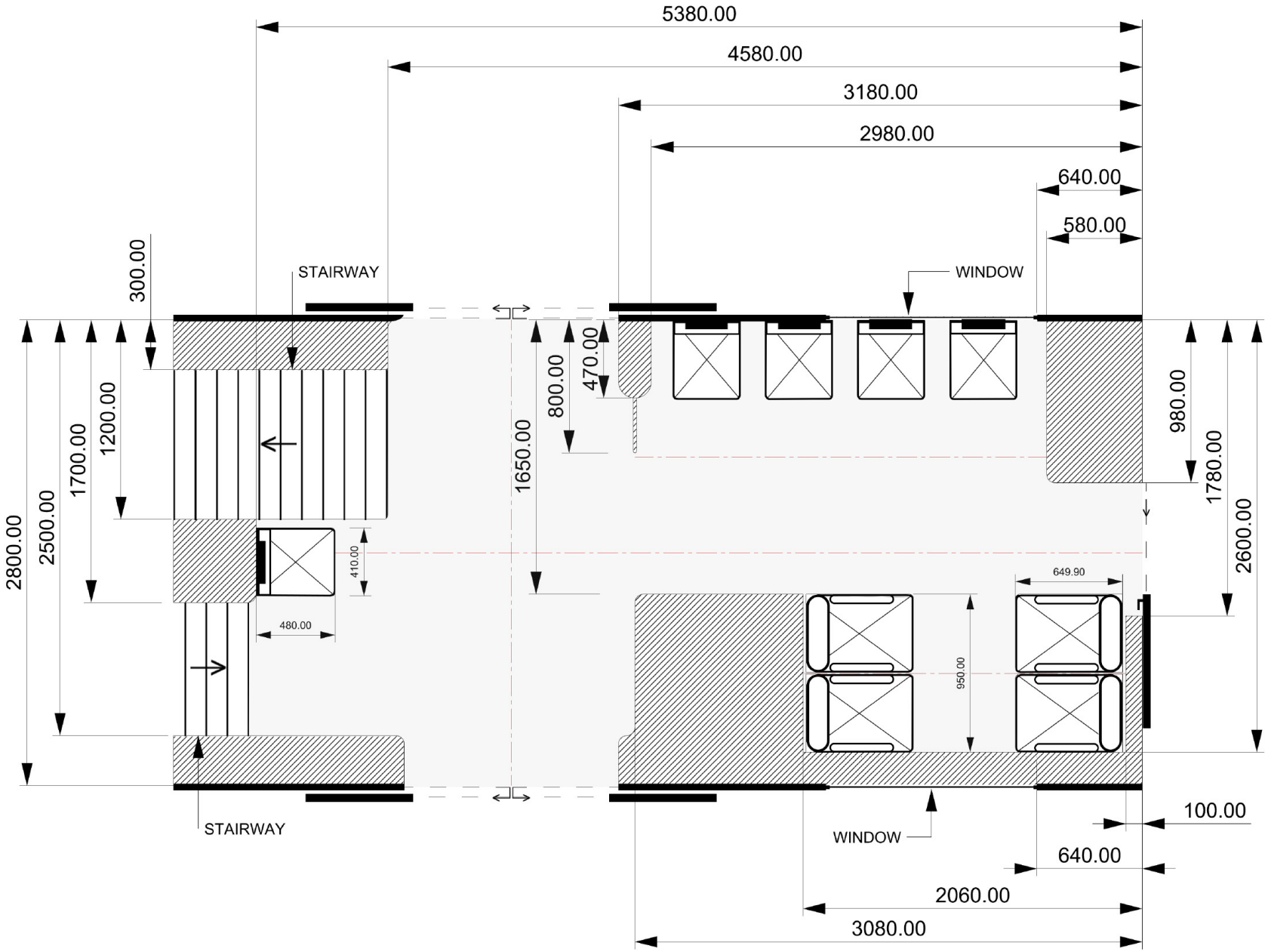

Figure A.1: vestibule ground plan- original layout in present-day NS trains.

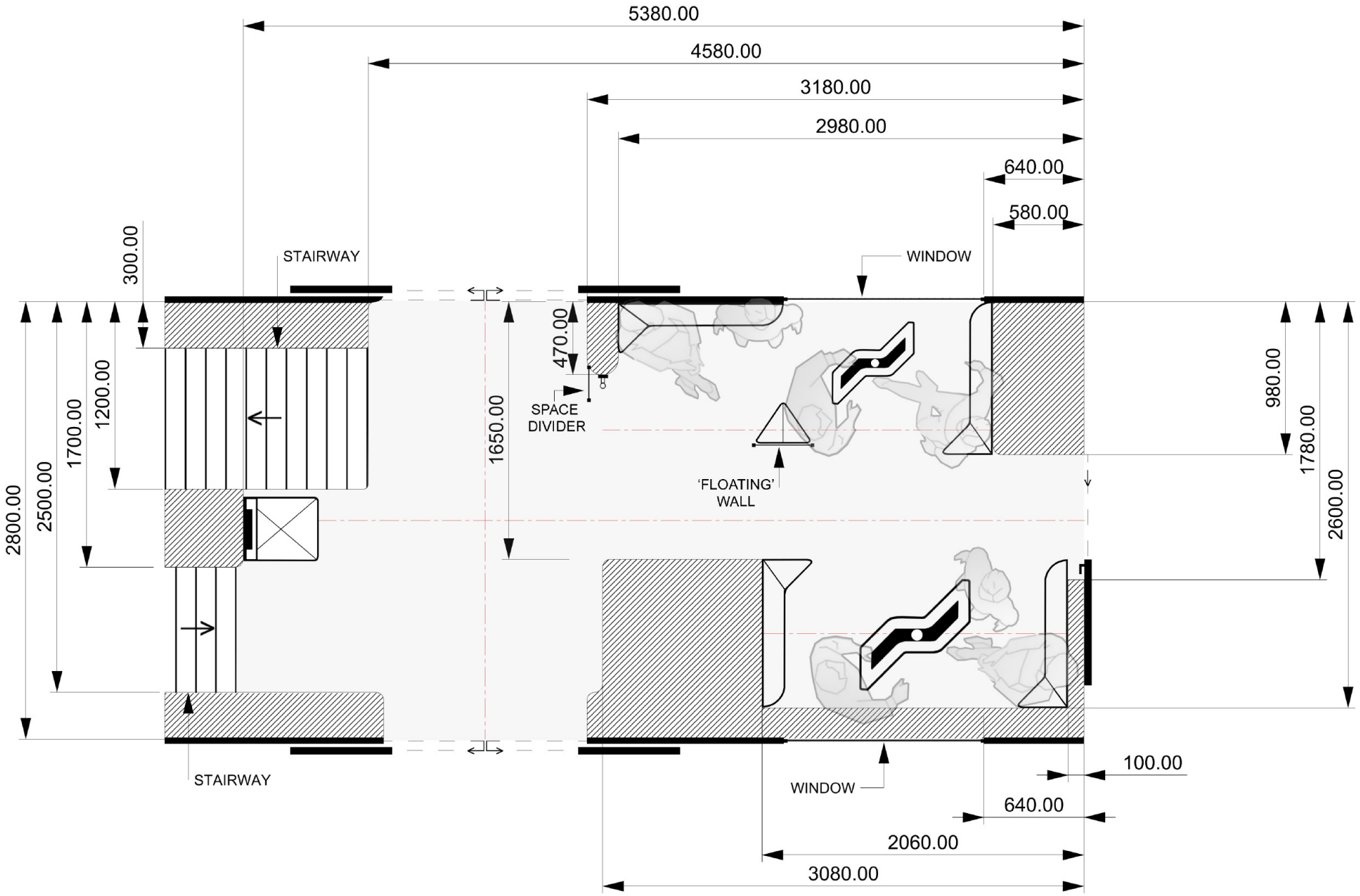

Figure A.2: vestibule ground plan- chosen layout with leaning post option #1.

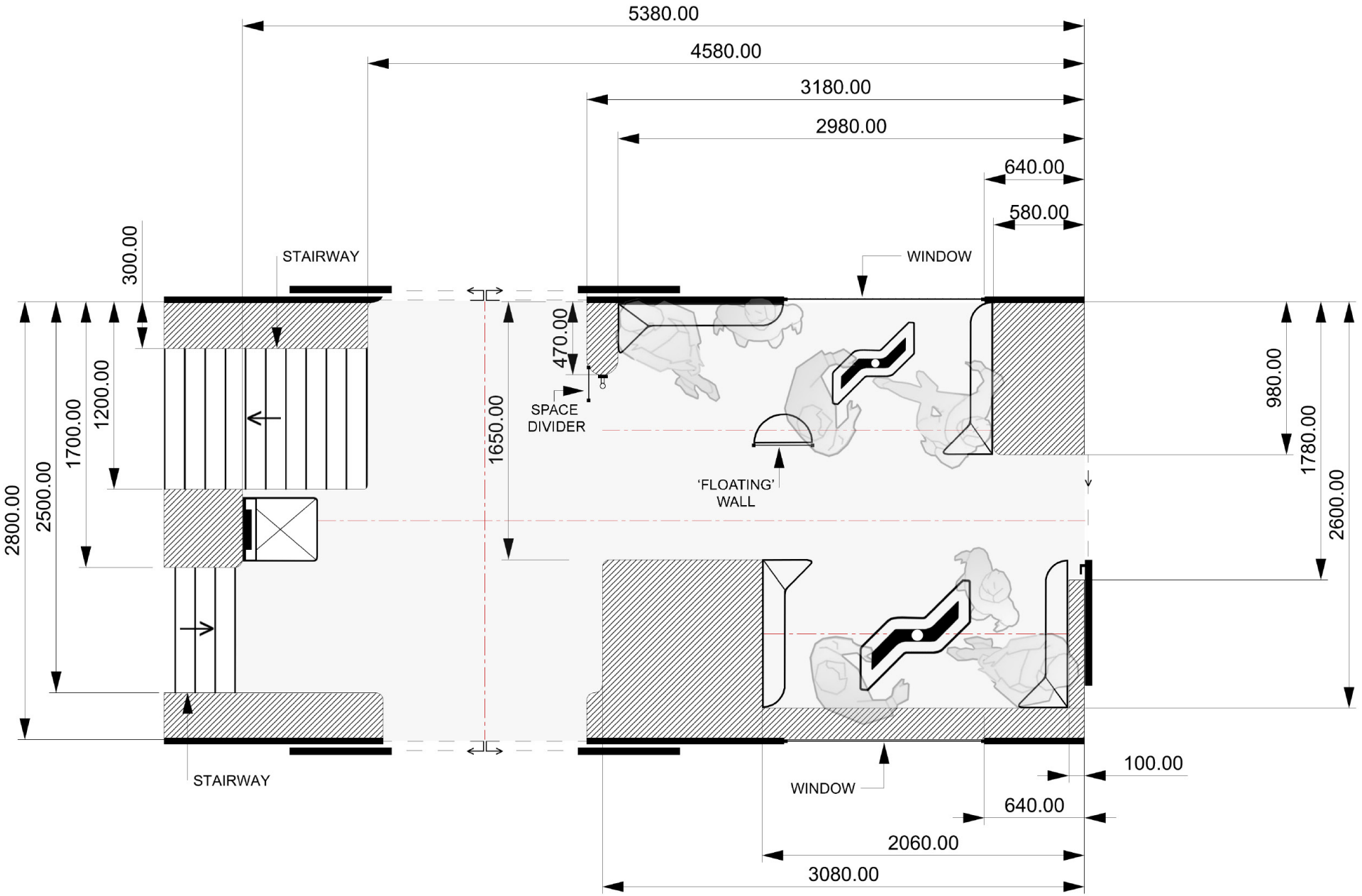

Figure A.3: vestibule ground plan- chosen layout with leaning post option #2.

	Current	Goal (1 year)	Vision
Customer (B2B)	Little contact to NS interior designers for feedback	Have contact with train companies like NS or Arriva. To get in contact with these companies, we propose our idea. Our main goal is to do research that is beneficial to the travellers' comfortable train journey. In addition, contact research department.	Work with or for public transport companies. Implementing research and getting data.
Customer (B2C)	Talk to some students who go regularly by train.	Having a group participant. Ranging from students to workers. Preferable participants going daily by train for longer than 30 minutes.	Create a comfortable space for general travellers when its busy in the vestibule space. Our research/design will help future projects determine what increases and decreases a comfortable traveler's journey in a train.
Product	Prototype of leaning bar. Final map layout. Concept of the divider and table.	Finished different iterations on all possible objects for the layout. Having working prototypes for testing and have a room with for simulation for in real life user testing.	Having the research implemented in trains. Where other projects can also learn from our research.
Team	3 students	Team of researchers and designers.	Department of a train company.
Cash (Income)	-	- Sponsors from university departments - Sponsors of public transport related companies - Funds - Selling ideas (maps + papers)	- Sponsors from university departments - Sponsors of public transport related companies - Funds - Selling ideas (maps + papers) - Working with and or for public transport companies.
Cash (Outcome)	-	- Material for prototyping and building - Renting room for simulation - Hire team - Patent	- Material for prototyping and building - Renting room for simulation (and power supply) - Hire team - Publish research - Material for production - Patent

Figure A.4: business canvas.

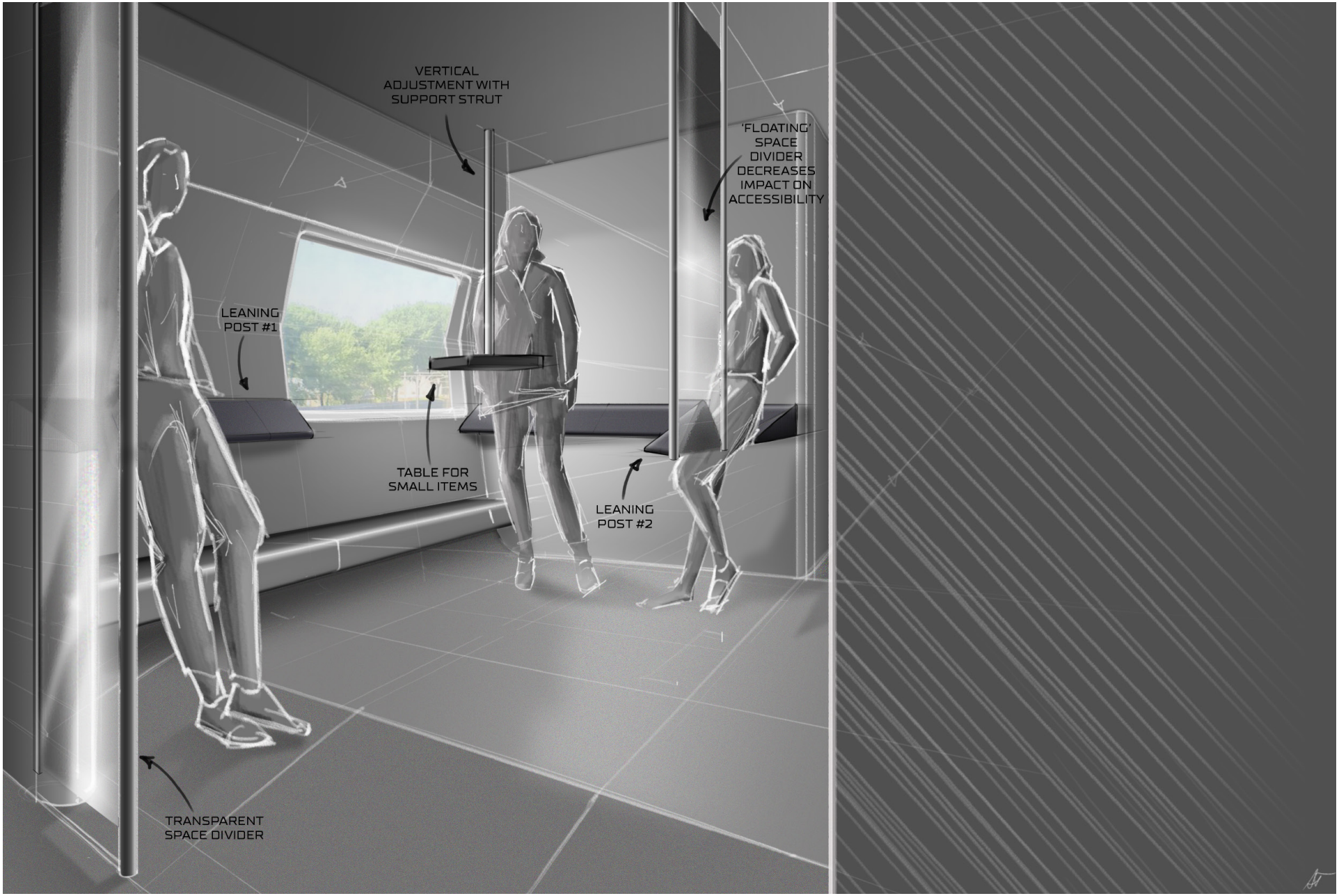

Figure A.5: Spatial illustration with leaning post option #1.

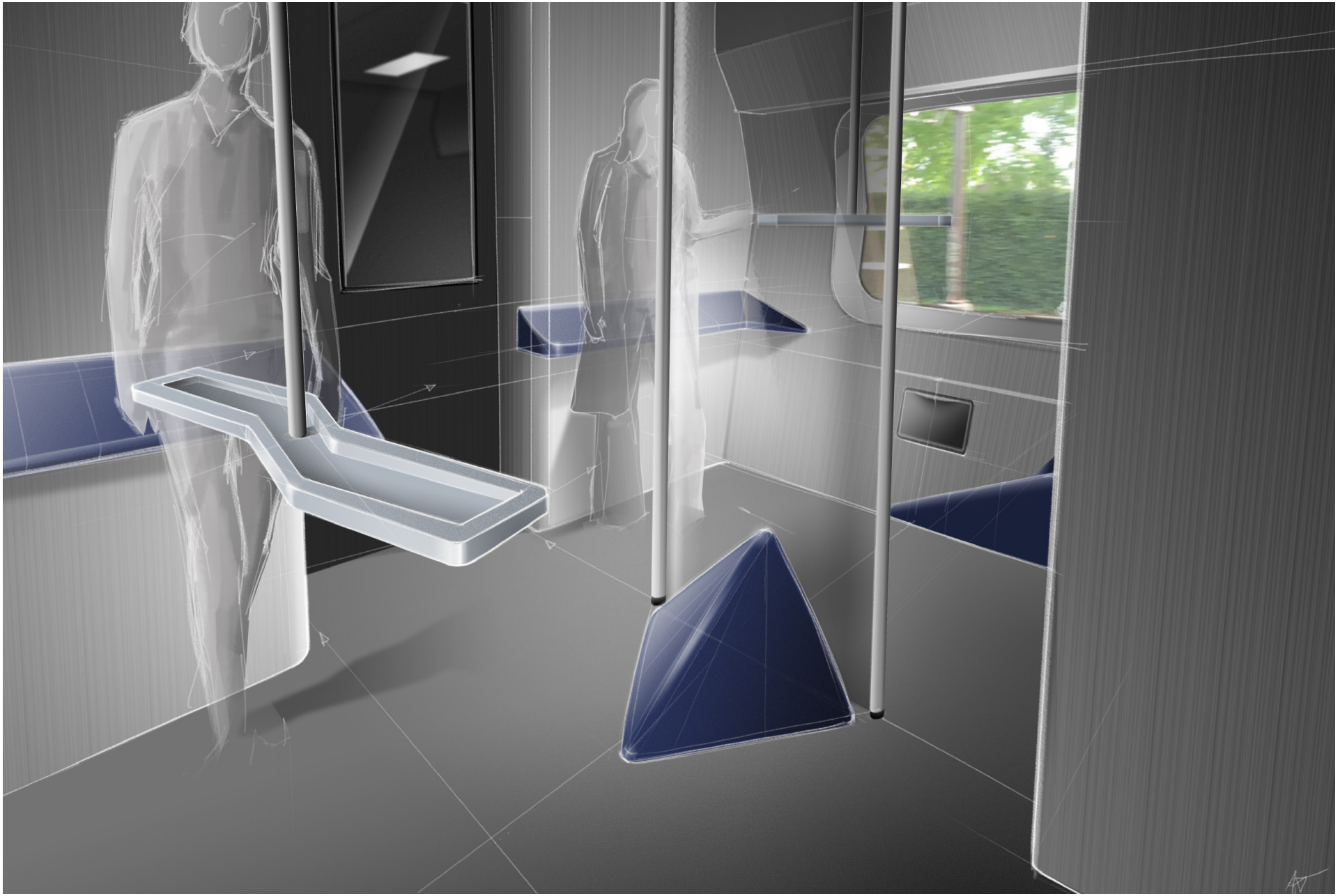

Figure A.6: Spatial illustration with leaning post option #1.

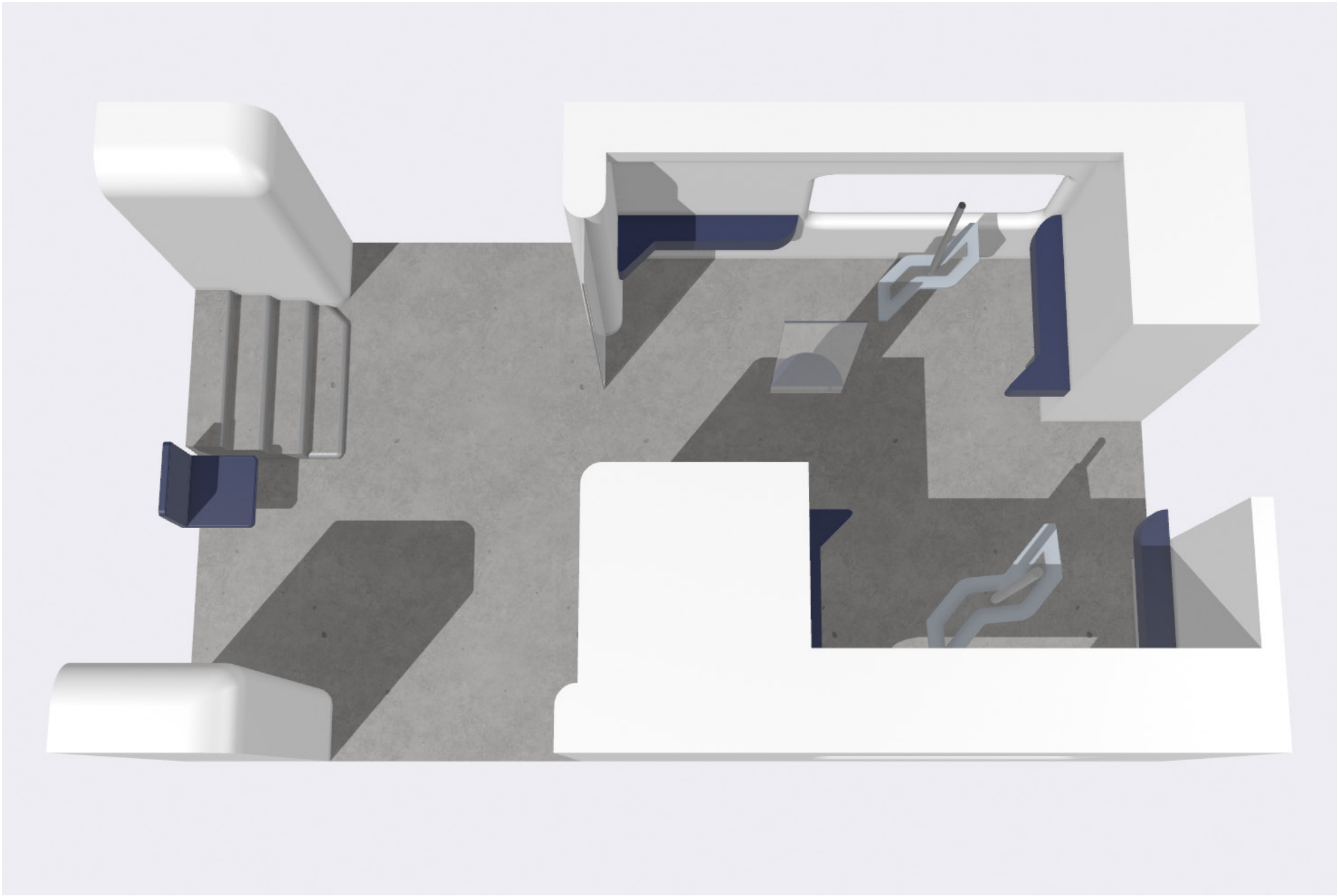

Figure A.7: CAD model of vestibule space, with leaning post option #2.

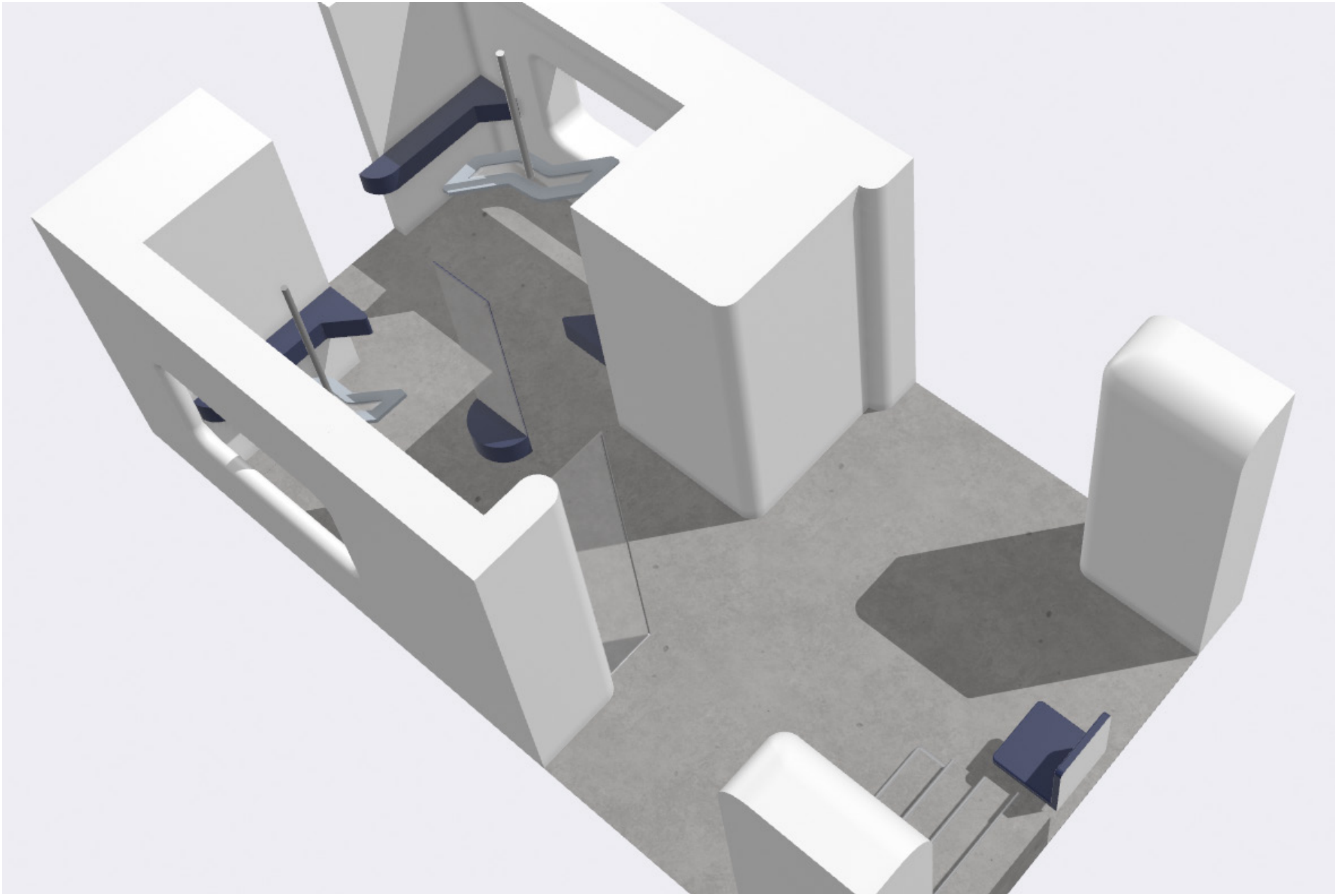

Figure A.8: CAD model of vestibule space, with leaning post option #2.