NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

# TRB Webinar:

# Planning Bus Operator Workstation and Barrier Designs for Health and Safety

*October 22, 2025*

*11:00 AM – 12:00 PM (eastern)*

# AICP Credit Information

One (1) American Institute of Certified Planners (AICP) Certification Maintenance (CM) Credit

You must attend the entire webinar

Log into the American Planning Association website (https://www.planning.org/) to claim your credits

Contact AICP (AICPCM@planning.org), not TRB, with questions

# Purpose Statement

This webinar will discuss how to mitigate the health and safety risks that are present for bus drivers. Presenters will share strategies for addressing these risks and highlight effective approaches to improve the design and management of bus operator workstations.

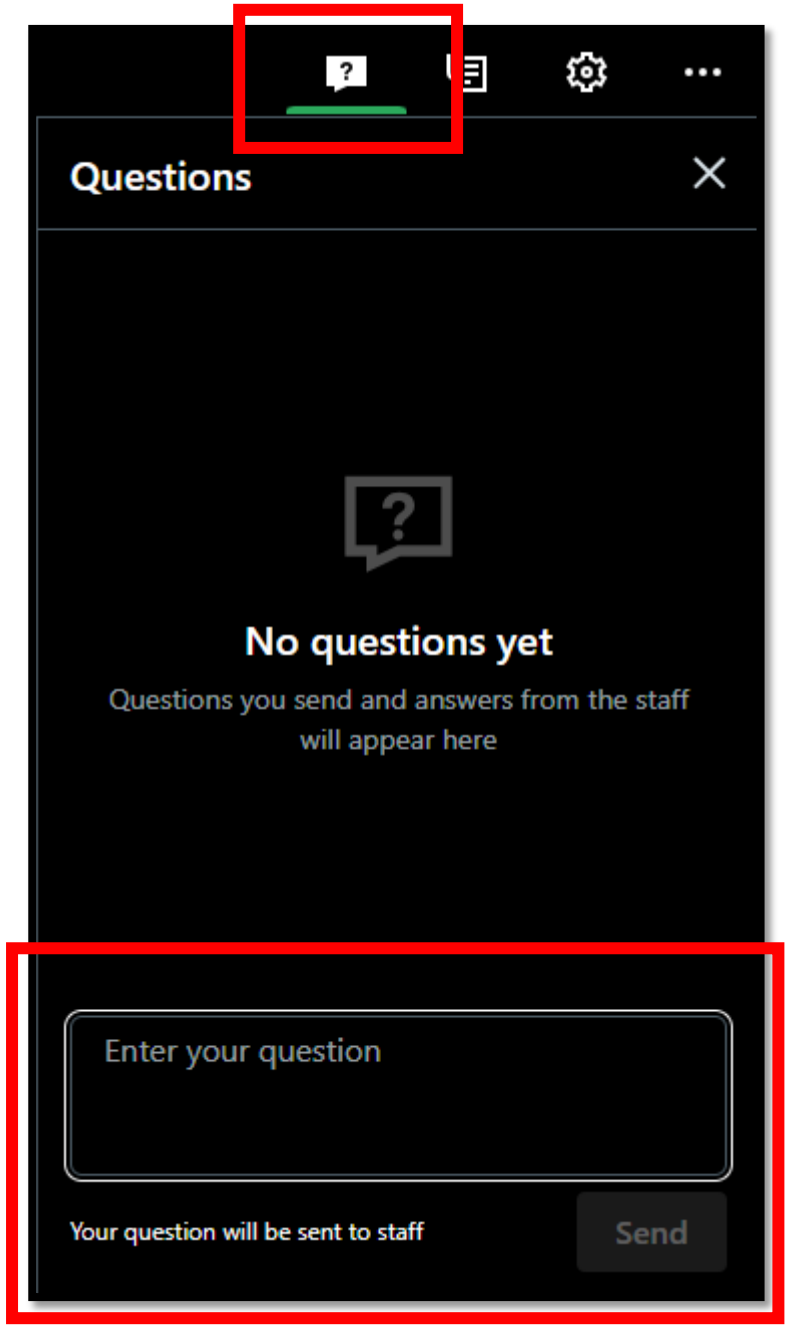
# Learning Objectives

At the end of this webinar, participants will be able to:

- Identify workstation features that would improve operator health, well-being, and performance
- Understand how human performance impacts the safe and efficient operation of the vehicle
- Apply practical, evidence-based guidance on designing bus operator barriers to protect the health and safety of bus operators and the traveling public

# Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



# *Today's Presenters*

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open design lab

# Bus Operator Workstation Design

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PennState
College of Engineering

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openlab.psu.edu

# Primary Research Area:
# **Design for Human Variability**

# We conduct research in the design of artifacts, tasks, and environments that are robust to the variability in users.

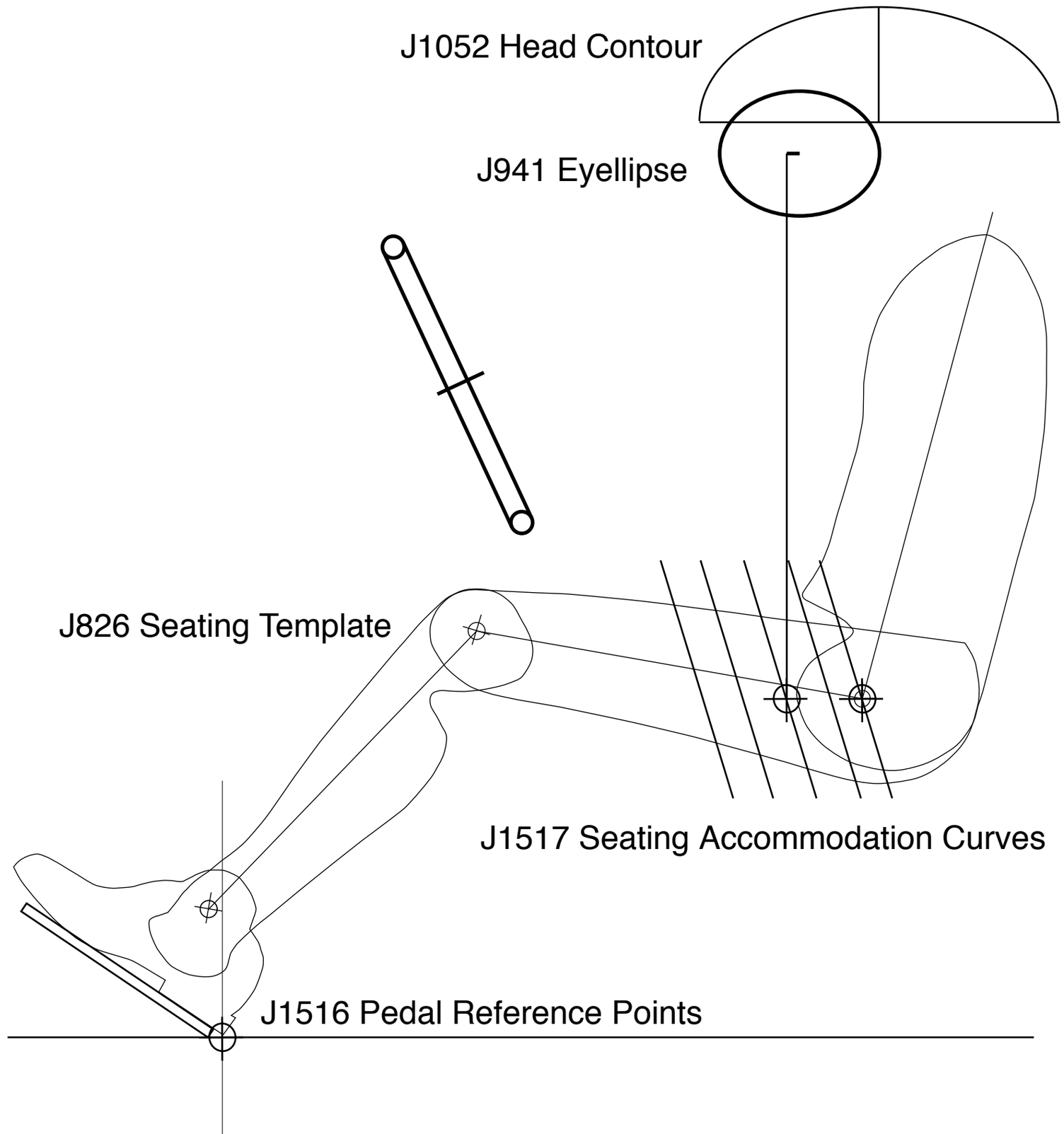
cars
**trucks**
airplanes
medical devices
implants
prosthetics
manufacturing
office furniture

**design practice and tools**
global anthropometry
data synthesis

# Problem: Bus drivers have one of the highest rates of injuries and illnesses of all occupations

# Objective: Improve bus packaging to make them safer and more comfortable

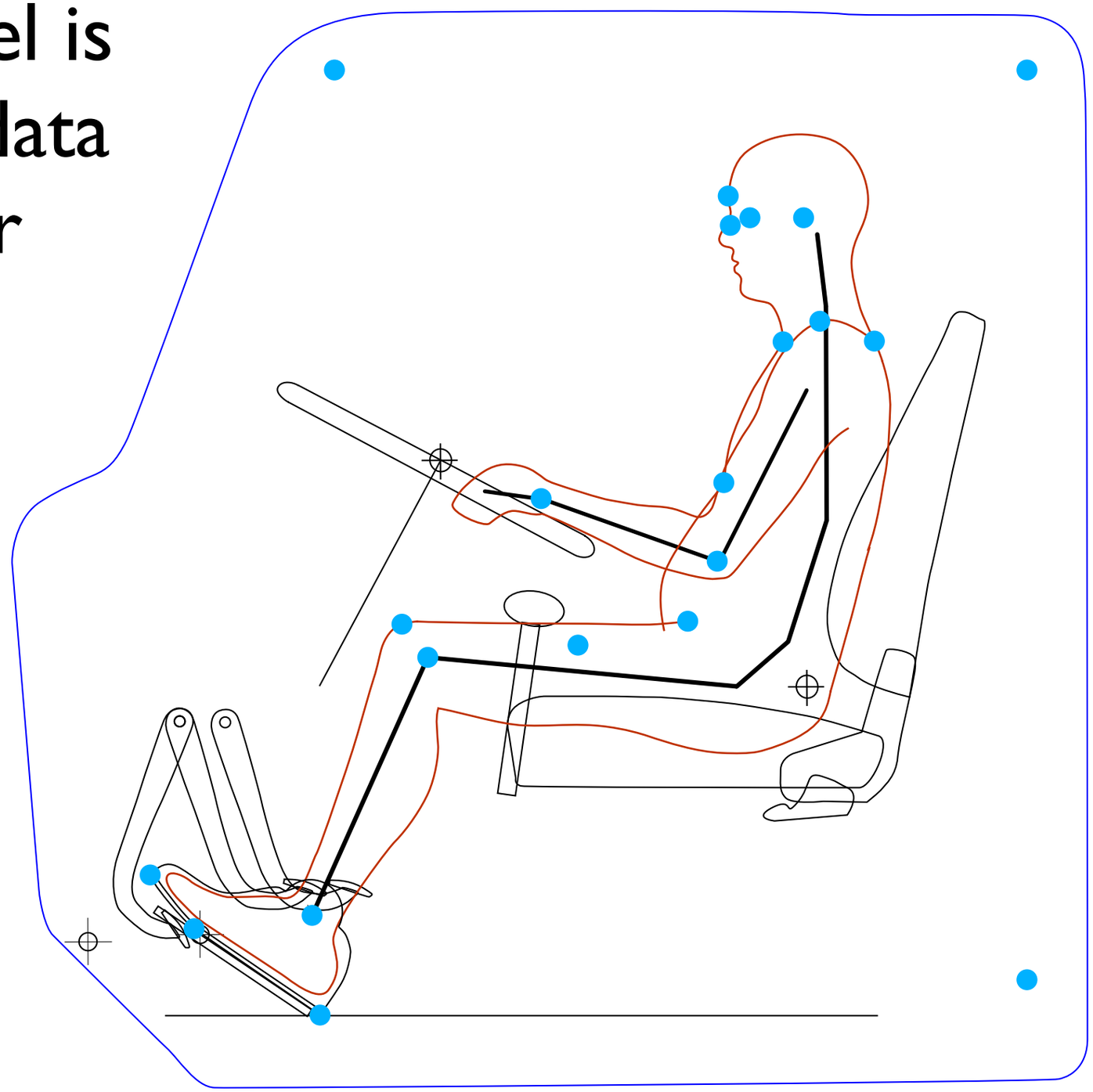
# Vehicle packaging usually considers a single measure at a time (e.g., SAE J-tools)



# We need to simultaneously consider all aspects of design (body dimensions and preference).

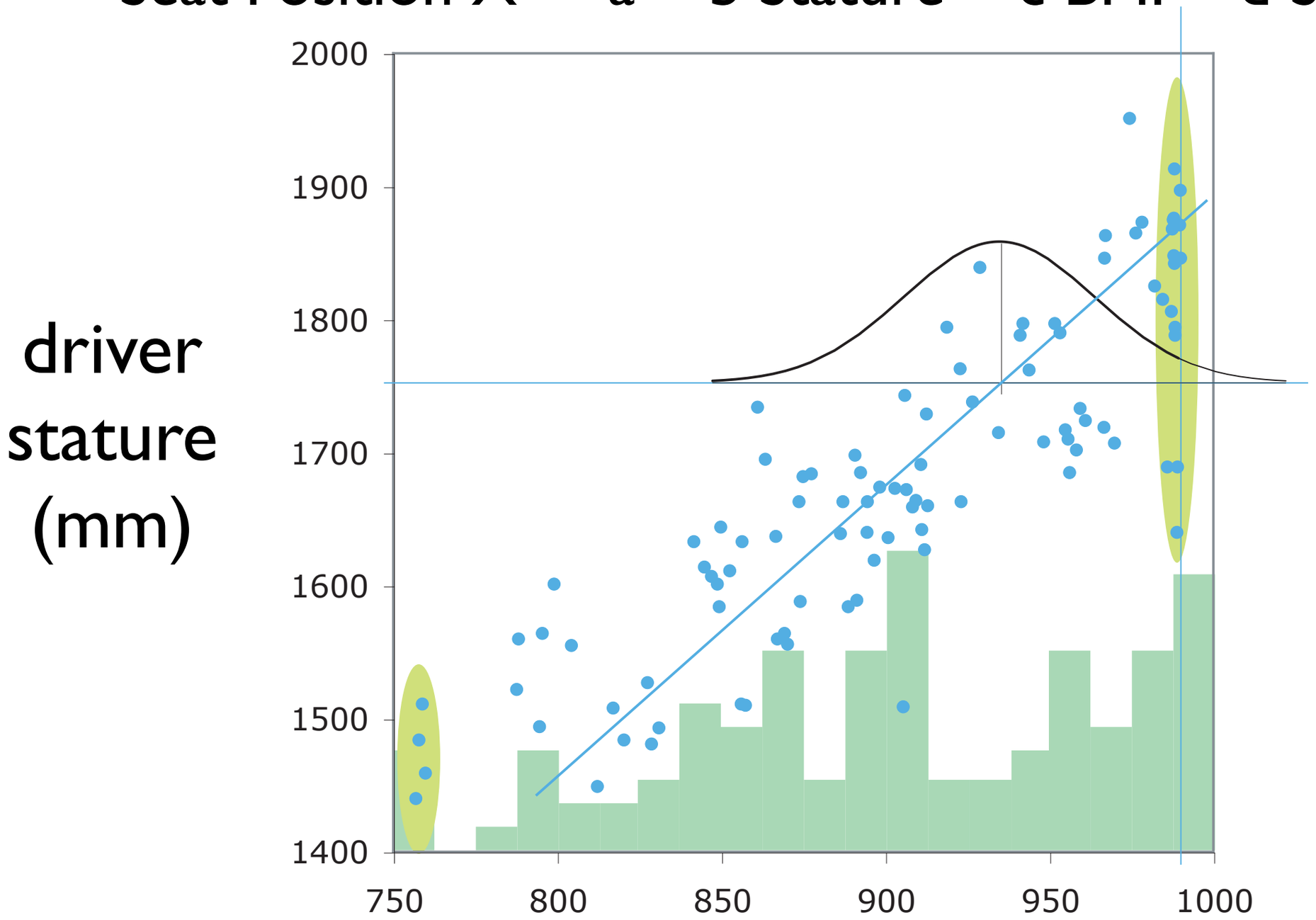
***Anthropometry in the Design of the Driver's Workspace***
**McFarland, R.A., Damon, A., and Stoudts, H.W. Jr. (1958)**

The UMTRI Cascading Posture Prediction Model is based on experimental data from participants in their own cabs and in a very adjustable buck.



# Resulting models predict the preferred location of components as a function of body size and shape.

Seat Position X = a + b Stature + c BMI + d SWX



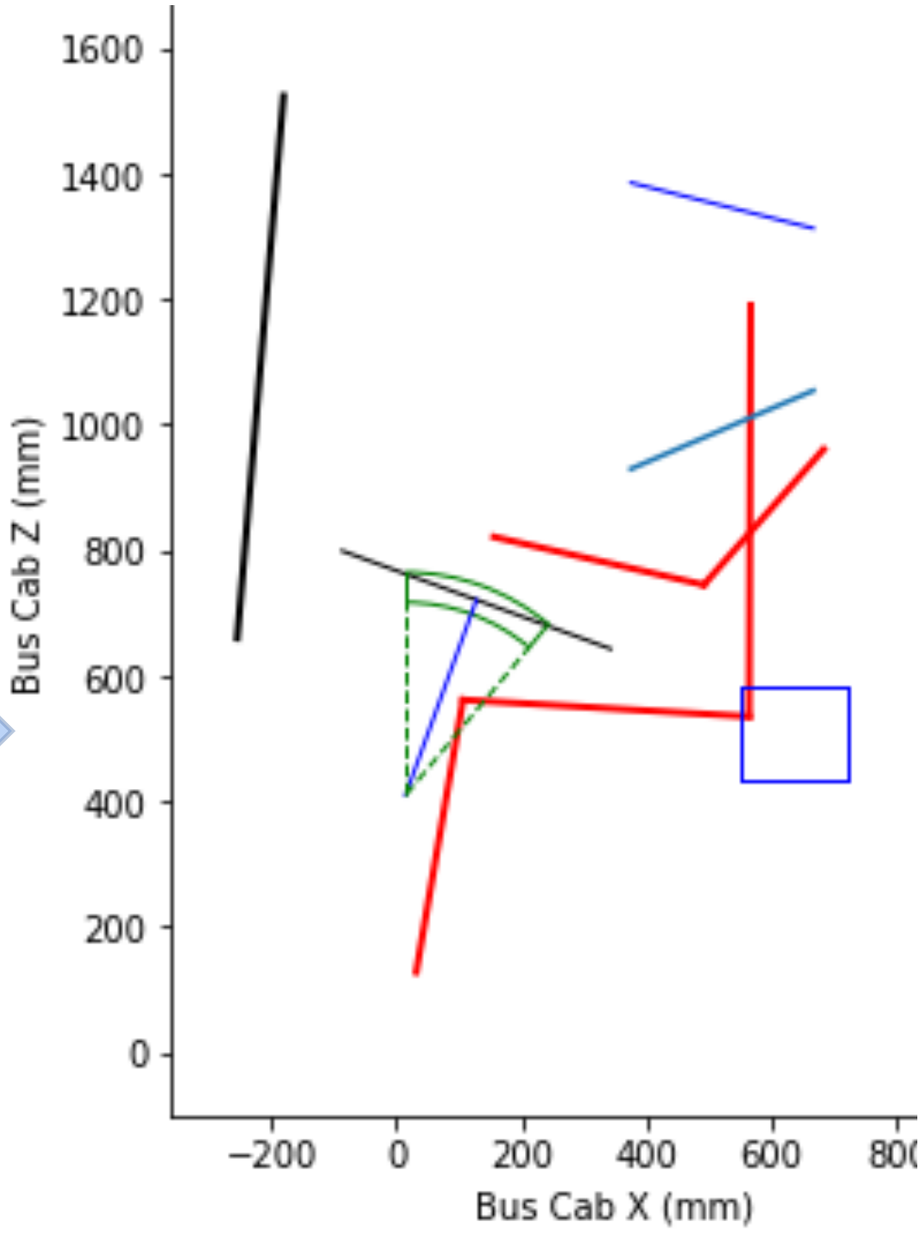

(Manary et al., 1998)

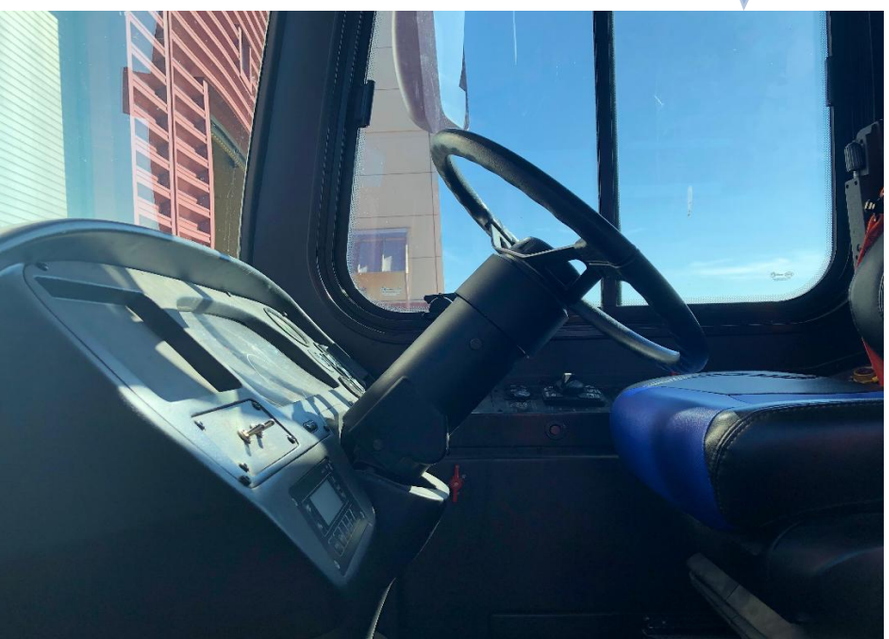
# The packaging assessment tool (Excel Spreadsheet) combines these models with driver population data and vehicle geometry.

driver dimensions

empirical posturing model

(Reed et al., 2002)

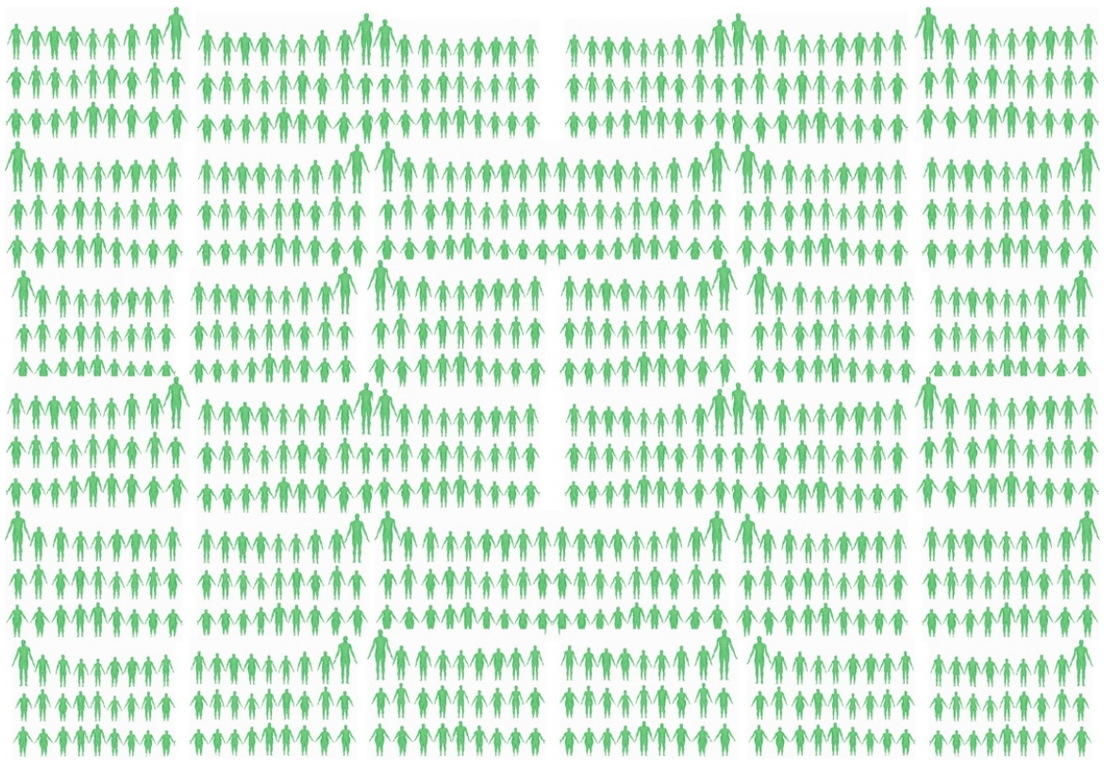


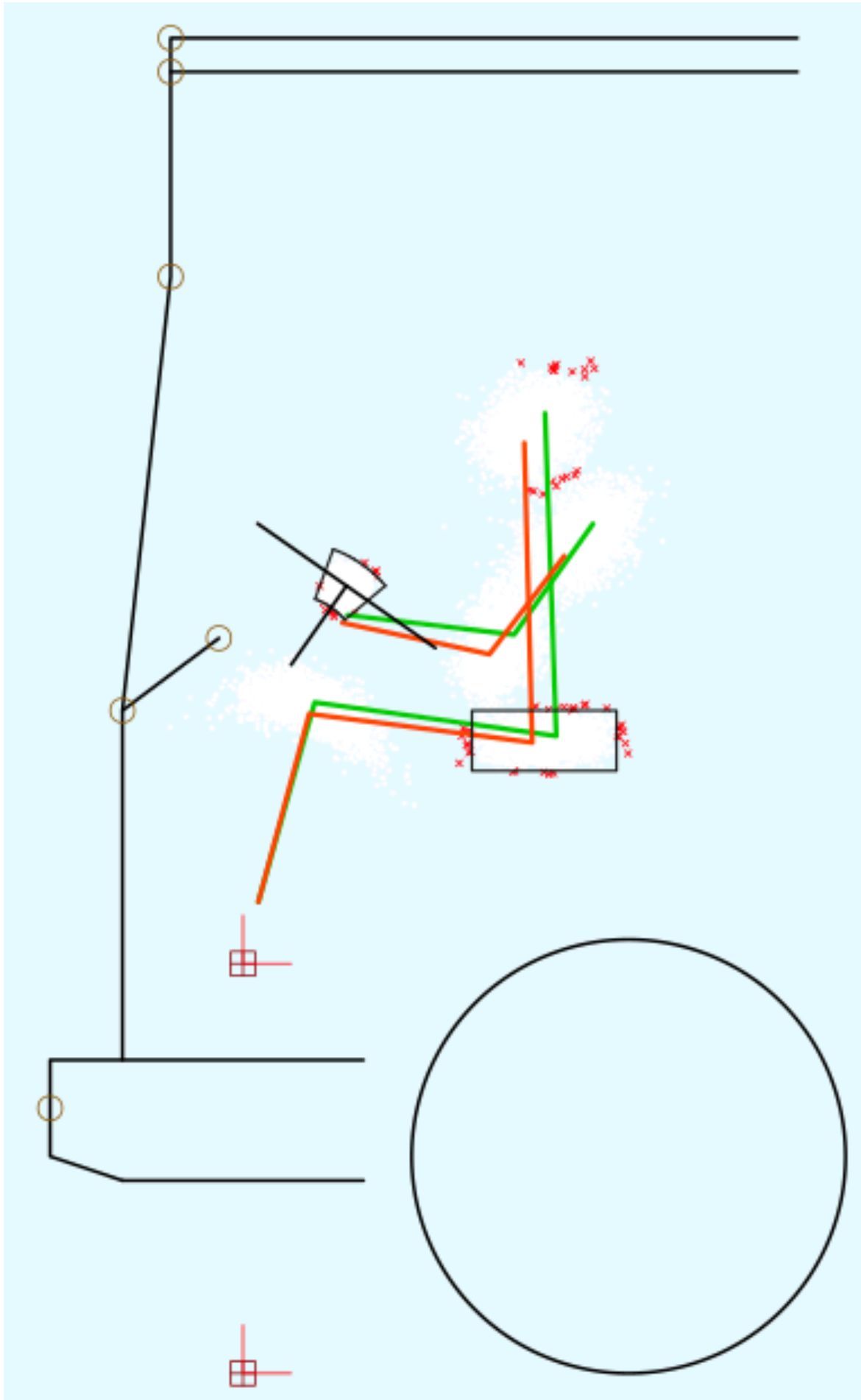
vehicle geometry

<u>preferred</u> steering wheel and seat positions for each driver

# We do this simulation for thousands of drivers representing the variability in the population.



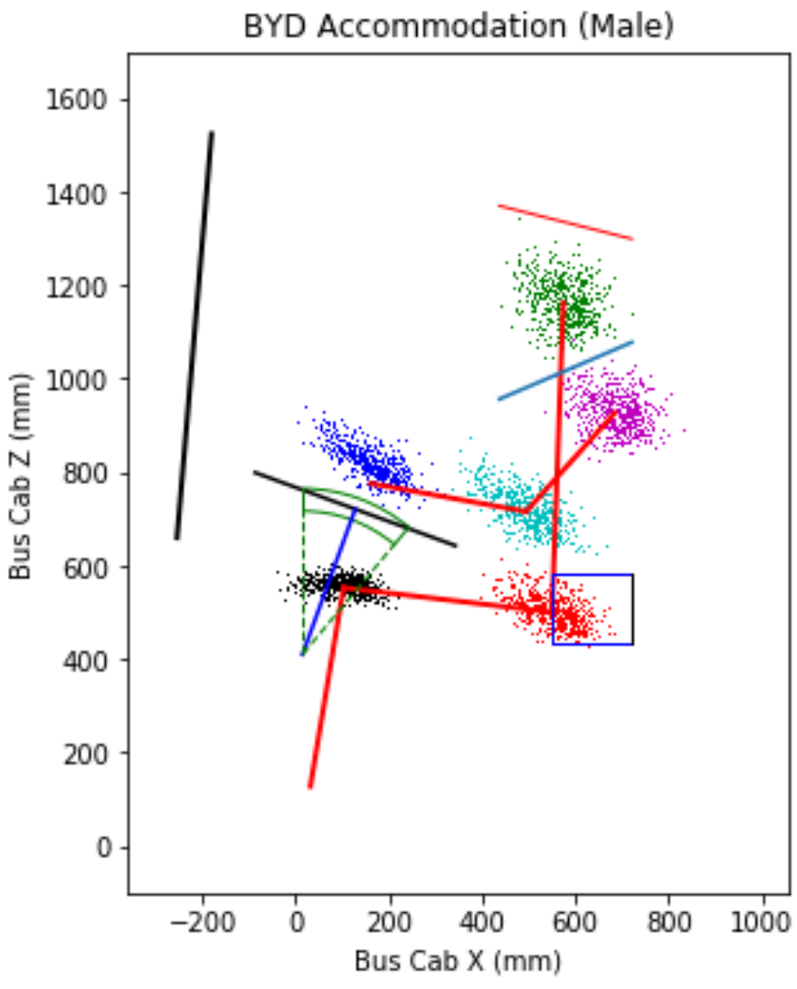
**Users that are unable to achieve their preferred position/posture for a given vehicle configuration are considered disaccommodated.**

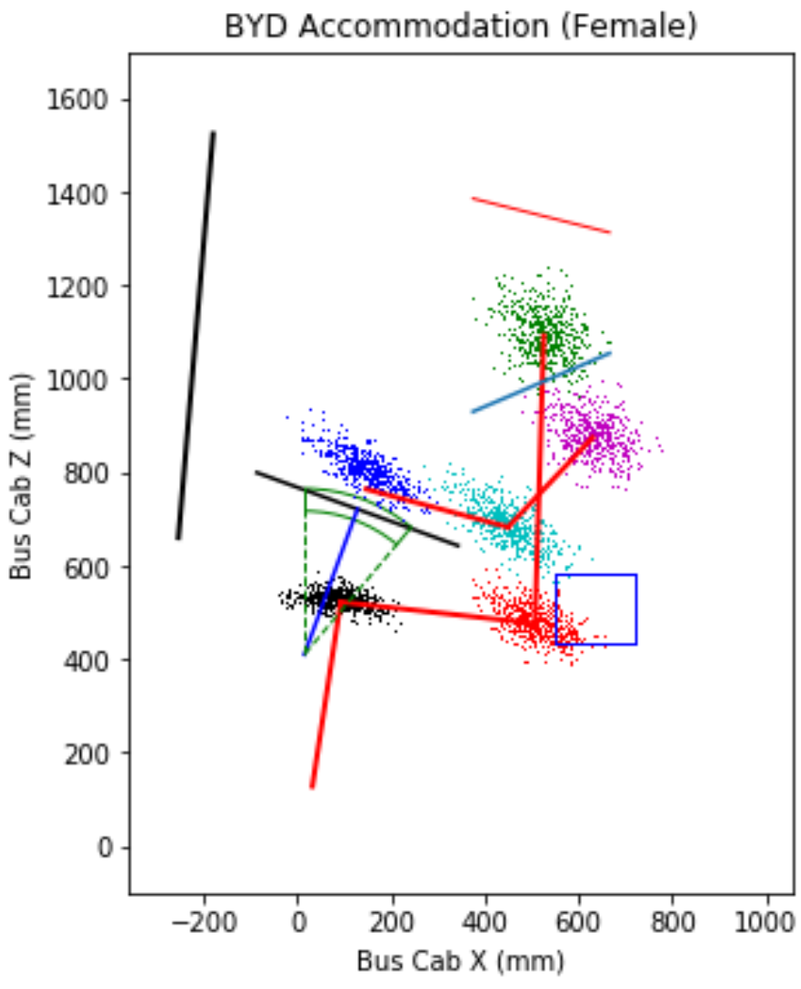


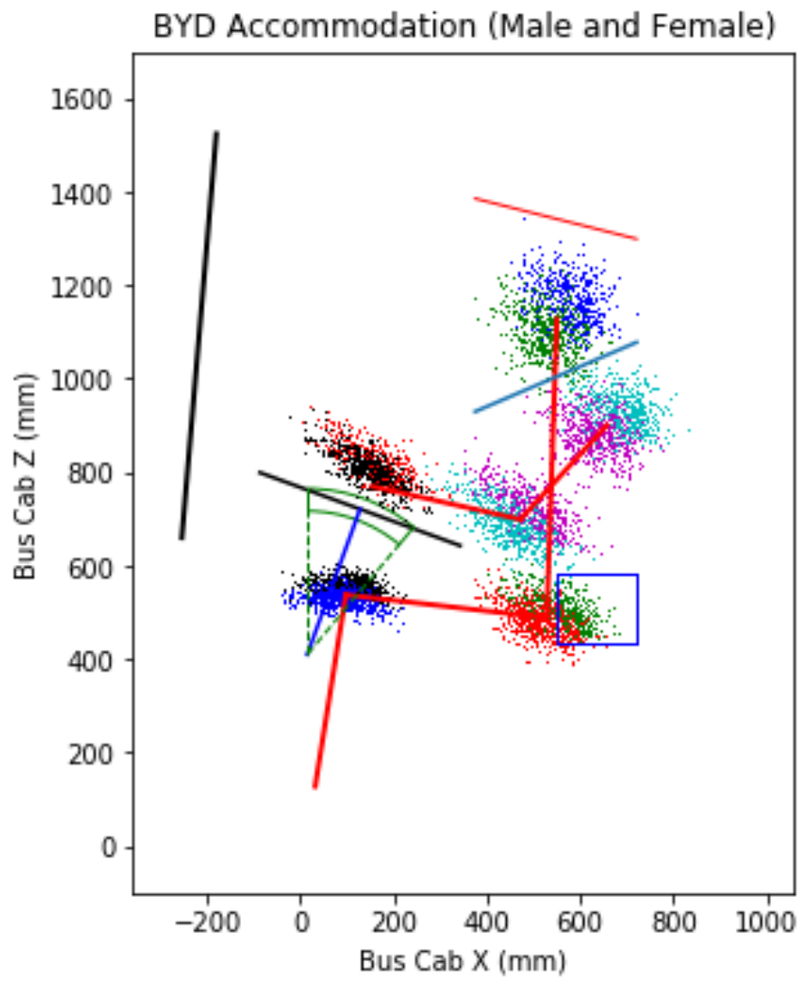
# Designers and contracting agencies can use the tool to assess candidate designs

| | | | | |
|---|---|---|---|---|
| VehicleClass | 1 | | SteeringWheelAngleMin | 0 |
| SeatTrackFDFFX | 551 | | SteeringWheelAngleMax | 40 |
| SeatTrackFDFFZ | 432 | | SeatBackAngleMin | 10 |
| SeatTrackFDFRX | 721 | | SeatBackAngleMax | 30 |
| SeatTrackFDFRZ | 432 | | SeatBackAngleDesign | 18 |
| SeatTrackFUFFX | 551 | | SeatInterferencePointX | 200 |
| SeatTrackFUFFZ | 582 | | SeatInterferencePointZ | 500 |
| SeatTrackFUFRX | 721 | | SeatBackPivotX | 100 |
| SeatTrackFUFRZ | 582 | | SeatBackPivotZ | -100 |
| SteeringWheelPivotX | | 15 | AHPX | 0 |
| SteeringWheelPivotZ | | 410 | AHPZ | 838 |
| SteeringWheelDiameter | | 457 | CowlPointX | -254 |
| TelescopeMin | 307 | | CowlPointZ | 1498 |
| TelescopeMax | 355 | | HoodPointX | -650 |
| | | | HoodPointZ | 650 |
| | | | UpperDLOX | -280 |
| | | | UpperDLOZ | 2362 |
| | | | RoofHeight | 2819 |
| | | | RoofThickness | 0 |
| | | | BackOfCabX | 0 |

# Many drivers are unable to achieve their desired locations—especially for the steering wheel



# The analysis results help us to understand where we need to modify our design.

Accommodation Summary - Male

| Head Under Roof | Seat Track Range | Steering Wheel | Up Vision | Down Vision | Total |
|---|---|---|---|---|---|
| 1.0 | 0.764 | 0.0 | 1.0 | 1.0 | 0.0 |

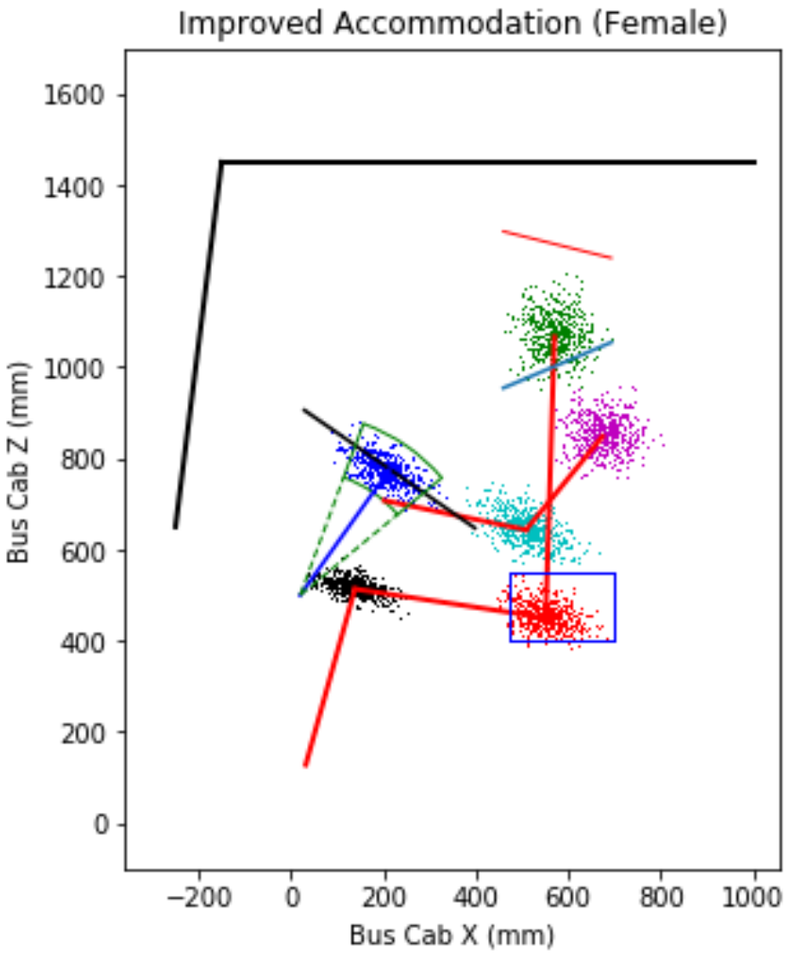
Accommodation Summary - Female

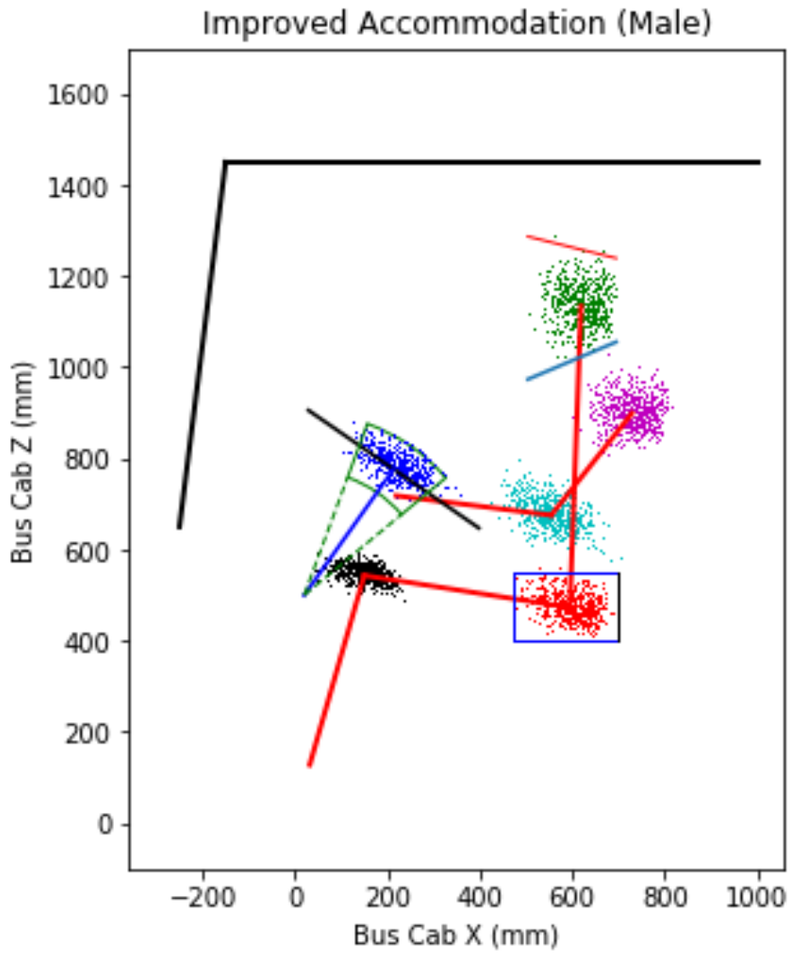
| Head Under Roof | Seat Track Range | Steering Wheel | Up Vision | Down Vision | Total |
|---|---|---|---|---|---|
| 1.0 | 0.386 | 0.01 | 1.0 | 0.952 | 0.002 |

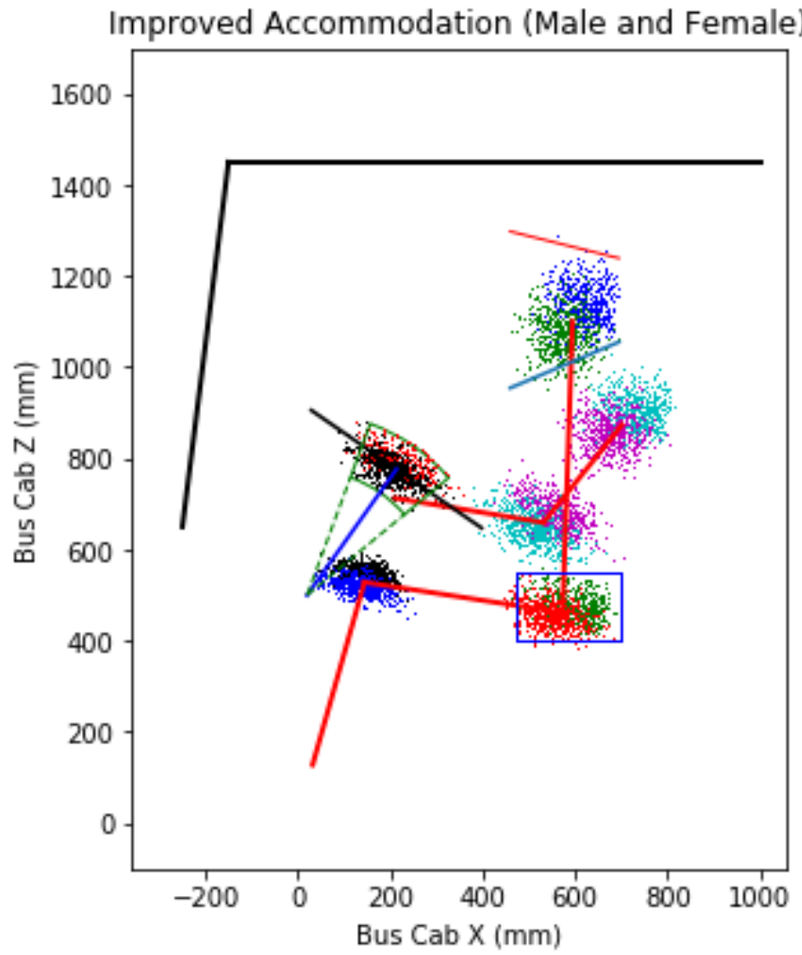
Accommodation Summary - Combined

| Head Under Roof | Seat Track Range | Steering Wheel | Up Vision | Down Vision | Total |
|---|---|---|---|---|---|
| 1.0 | 0.575 | 0.005 | 1.0 | 0.976 | 0.001 |

# The improved design repositions the steering wheel and seat track and adds some adjustability.



# The improved design works better for both men and women.

Accommodation Summary - Male

| Head Under Roof | Seat Track Range | Steering Wheel | Up Vision | Down Vision | Total |
|---|---|---|---|---|---|
| 1.0 | 0.914 | 0.944 | 0.996 | 1.0 | 0.876 |

Accommodation Summary - Female

| Head Under Roof | Seat Track Range | Steering Wheel | Up Vision | Down Vision | Total |
|---|---|---|---|---|---|
| 1.0 | 0.966 | 0.906 | 1.0 | 0.91 | 0.842 |

Accommodation Summary - Combined

| Head Under Roof | Seat Track Range | Steering Wheel | Up Vision | Down Vision | Total |
|---|---|---|---|---|---|
| 1.0 | 0.94 | 0.925 | 0.998 | 0.955 | 0.859 |

Bus Accommodation Model 2020

Choose A Population (click to Expand).

**Select Driver Database:**

NHANES Drivers

**Select 'Male - Female Ratio':**

50% - 50%

Steering Wheel in 'mm/degree'. (X:AHP Z:AHP)

Seat Track in 'mm'. (X:AHP Z:AHP)

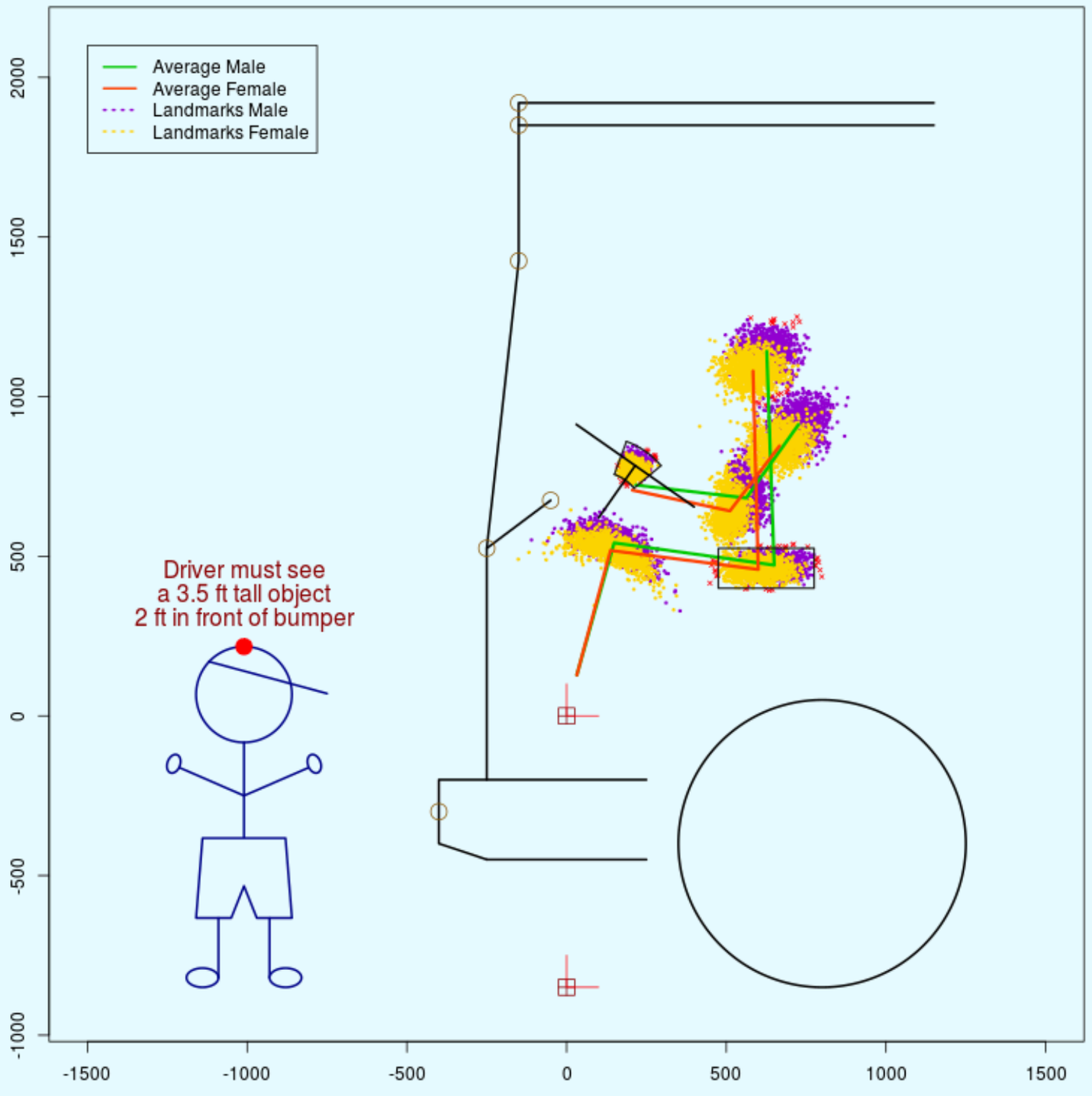
Geometric Layout in 'mm'. (X:GND)

Update Accommodation

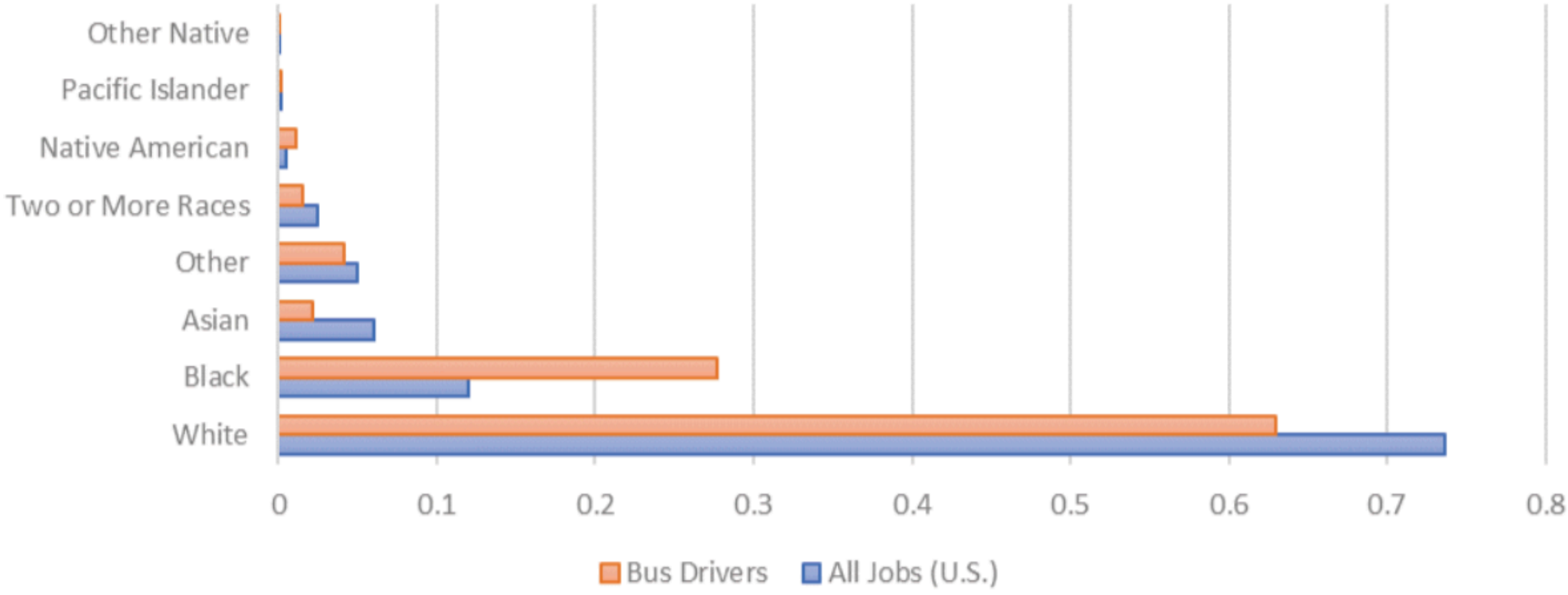
Instruction | Data Visualization | Magnified View | Accommodation Summary | Acknowledgement

*[1] Move cursor onto the graph to enable more actions*

☑ Male Landmarks ☑ Female Landmarks ☑ Average Male ☑ Average Female ☐ Disaccommodated Users Only



# We can also explore accommodation for drivers based on factors like race and ethnicity




US Bus Driver Racial Diversity (2018)

# The tool and associated report are available from the *National Academies Press*

# open design lab

We conduct research in the application of rigorous design methods to the design of artifacts, tasks, and environments for people.

## data

explore and download data for US civilians, global populations, NHANES, ANSUR, and ANSUR II

download data

## design

make design decisions using our customizable design tools and data on body size and shape

tools

## learn

learn from our how-to guides, research publications, primers, and other materials

library

Navigating the barriers to interdisciplinary design

Using Multivariate Analysis to Select Accommodation

search

Search

openlab.psu.edu

# thank you

matt parkinson
parkinson@psu.edu

**TRB WEBINAR:**

***PLANNING BUS OPERATOR WORKSTATION AND BARRIER DESIGNS FOR HEALTH AND SAFETY***

# *TCRP REPORT 249 (PROJECT C-25)*

# *BUS OPERATOR BARRIER DESIGN: GUIDELINES AND CONSIDERATIONS*

ANDREW KRUM

OCTOBER 2025

VIRGINIA TECH
TRANSPORTATION INSTITUTE

TRANSPORTATION RESEARCH BOARD
*OF THE NATIONAL ACADEMIES*

# NEED

- Average of 174 instances (NTD reported/major) of operator assault per year between 2009 and 2018. [1]
- NTD documents a 120% increase in assaults against transit workers from 2013 to 2021.[2]
- Non-fatal assaults can be routine and, in the past, often were unreported (Memphis Area Transit Authority).[3]
- Preventative methods such as barriers and self defense training and tools may be the only methods to deflect spontaneous assaults. [4]


1. FTA, February 2021 https://www.transit.dot.gov/sites/fta.dot.gov/files/2021-02/February-Spotlight-Operator%20Assault-20210223.pdf
2. "FTA issues general directive to help transit agencies protect frontline workers from risk of assaults" (9/26/2024) https://www.masstransitmag.com/safety-security/press-release/55142761/federal-transit-administration-fta-fta-issues-general-directive-to-help-transit-agencies-protect-frontline-workers-from-risk-of-assaults
3. Transit Advisory Committee for Safety (TRACS) 14-01 Report, Preventing and Mitigating Transit Worker Assaults in the Bus and Rail Transit industry, July 6, 2015.
4. Nakanishi, Y.J. & Fleming, W.C. (2011). TCRP Synthesis 93: Practices to Protect Bus Operators from Passenger Assault. Transportation Research Board, National Academies. Washington, D.C.

# OBJECTIVE

Provide practical guidance to industry and transit agencies…

- Design
- Procurement
- Installation

on transit bus barriers that enhance…

- Retrofit existing bus operator workstations
- Conceptualize future bus operator workstations

the health and safety of bus operators and the public.

- Operating visibility
- Protection and security
- Comfort, temperature, and human factors
- ADA compliance
- Emergency egress
- Air quality

# TEAM

## IDENTIFY NEEDS ● DEFINE REQUIREMENTS ● ENGINEER CONCEPTS ● EVALUATE ● PRODUCE GUIDANCE

Future Bus Barrier Concept

Barrier Needs, Requirements and Interfaces

Agency Outreach Support

Guidance, Review and Approval

# IDENTIFY NEEDS

## TRANSIT SURVEY

# TRANSIT SURVEY

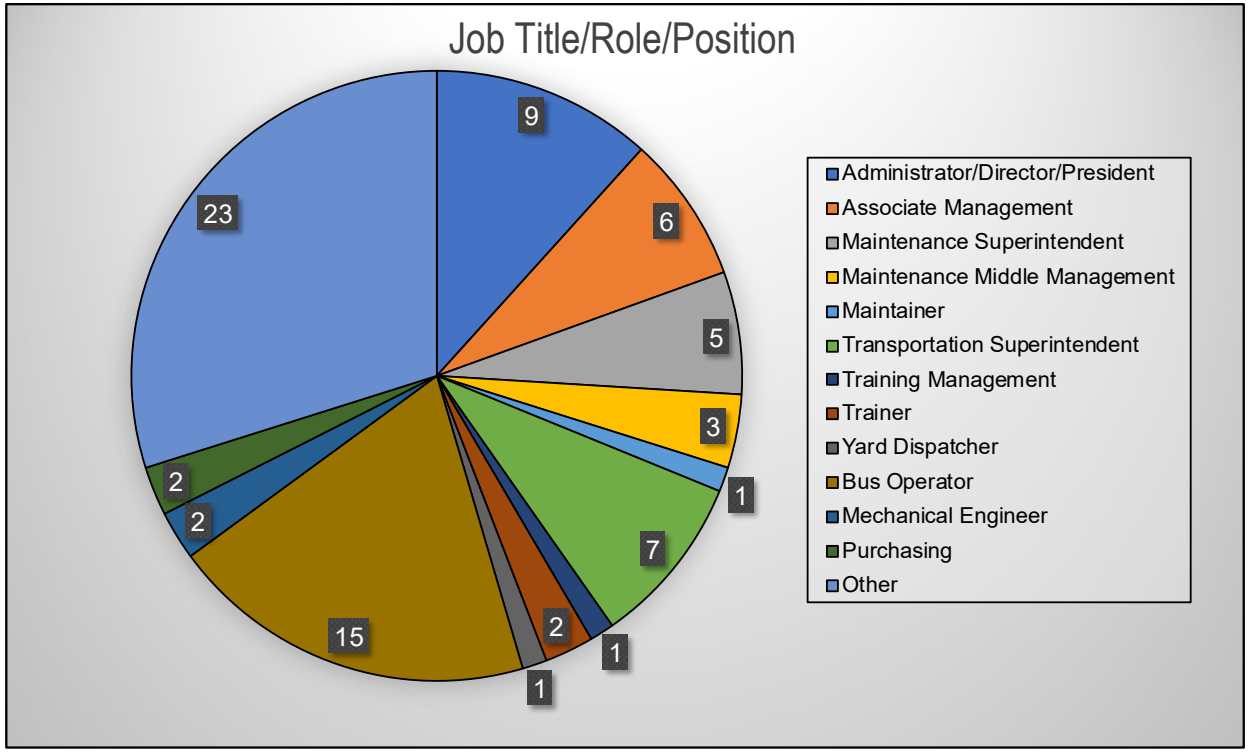
## GOAL

- Types of barriers in use
- Primary reason for barrier use
- Plans to continue using barriers
- Positive and negative comments from bus operators
- Costs to implementation and return-on-investment
- What an ideal barrier would/should be

# TRANSIT SURVEY

## DEMOGRAPHICS

- Collection from up to 77 respondents from across North America
- 49 identified agency; others did not complete organization question
- Timeframe: Fall 2022 / Winter 2023
- Respondents included management, drivers (bus operators), maintainers, engineering, and purchasing roles
- Average years of experience (n = 53)
  - All 9.7; minimum 1; maximum 34
  - Administration: 8.4
  - Maintenance: 6.3
  - Transportation: 14.7
  - Engineering/Procurement: 3.5



# TRANSIT SURVEY

## RESULTS

- Agency Barrier Current Use 96% (n = 54)
  - Regarding use before/after COVID-19 (n=51)
    - **31% use before COVID-19** for:
      - Prevention of physical assault: 69% (11)
      - Bus operator health (e.g., sneeze guard, etc.): 6% (1)
      - Both: 13%  (2)
      - Other : 13% (2)
    - **69% use after COVID-19**
      - 100% respondents said agencies will continue to use as pandemic wanes
    - **92% of 50 respondents** said their agencies required barriers be used
  - Three (3) respondents said agencies do not use but considering
    - Why not before now? **No assaults, concern for emergency evac., more research/info needed**

# TRANSIT SURVEY

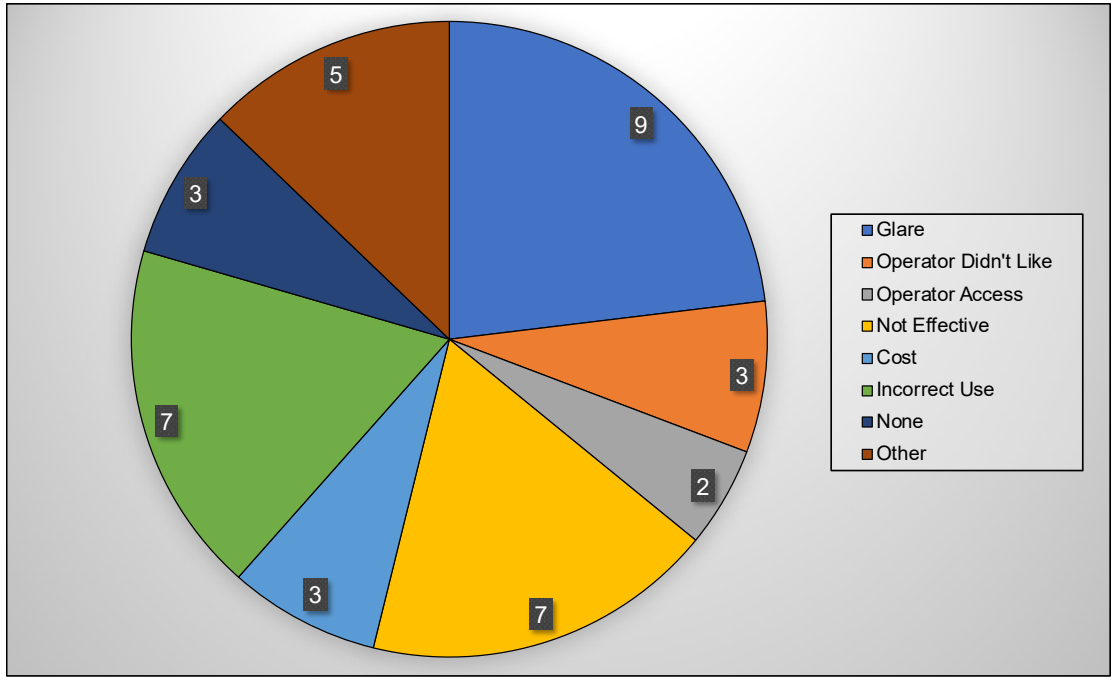
## RESULTS

- Barrier Design (n = 37)
  - Types:
    - Vinyl shower curtain
    - Full plexiglass or polycarbonate enclosure
    - Steel half barrier door
    - Full barrier with steel lower half and sliding plexiglass or glass upper half; powered windows and separate fan controls
    - Upper half opens separately from lower half
  - **Redesign or evaluation** of lessons learned since initial installation: 41%
  - Manual versus automatic to open close: Majority are manual; automatic or partially automatic
  - Barriers ADA (n=39): compliant 74%, unknown 23%
  - Allows **emergency egress** (i.e., disengage barrier and open): 59%
  - Design considers the **visibility and glare concerns** of bus operators: 54%

# TRANSIT SURVEY

## RESULTS

- Effectiveness
  - Challenges implementing (n = 39) →




  - Bus operator training (n=33): 49%
  - Benefits (n=31)
    - **Reduction in assaults 32%**
    - **Operator protection or confidence 19%**
    - **Other benefits mentioned: reduced operator sick days, reduced bus operator injury, general and contained airborne pathogens**
    - **Unknown/none: 35%**
  - Complaints (n=31) exist from bus operators 67% and passengers 6%
  - Return on Investment
    - Unknown or not applicable: 89%
    - Factors: reduce assaults, workers comp claims, prevent bus operator sickness
  - **Successful 39%, Partly successful 42%, Unsuccessful 19%**

# ENGINEER CONCEPTS

## CONFIGURATIONS AND RISK MITIGATION

# BUS BARRIER CONCEPTS FOR RISK MITIGATION

## Three configurations developed to support retrofit and new vehicles.

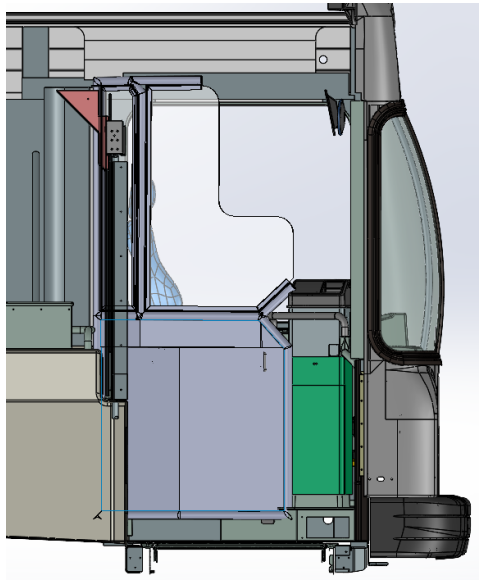
- Seeking to provide options at varying cost and complexity with risk control features that align with a range of decision maker and stakeholder preferences.

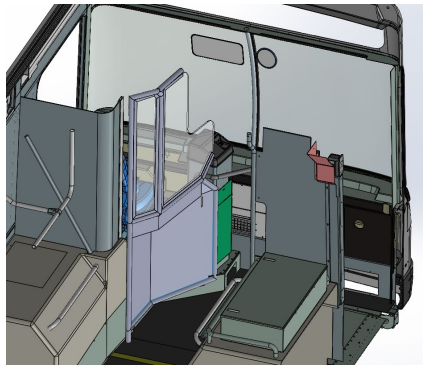
| | | | Risk Controls | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Concept | Type | Cost | Physical | Spitting | Air | Thermal | ADA | Usability | Visibility |
| A | Retrofit | Low | medium | low | low | low | **high** | medium | medium |
| B | Retrofit | Moderate | **high** | **high** | medium (pressure) | medium | **high** | **high** | **high** |
| C | Integrated | High | **high** | **high** | **high (filtration)** | **high** | **high (mid-door)** | **high** | **high** |

# BENCHMARKING

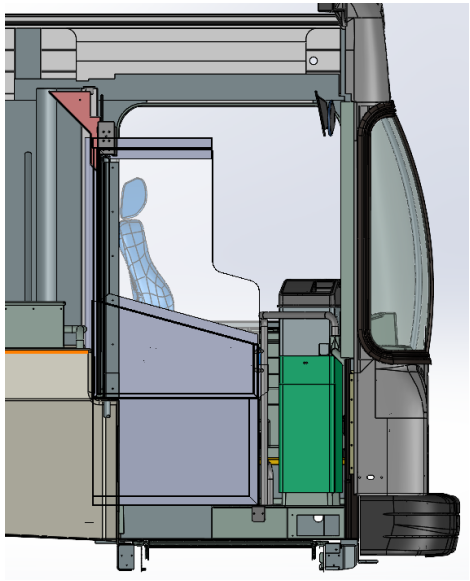
## Comparison of three existing NYCT retrofit bus operator barriers to new retrofit concept

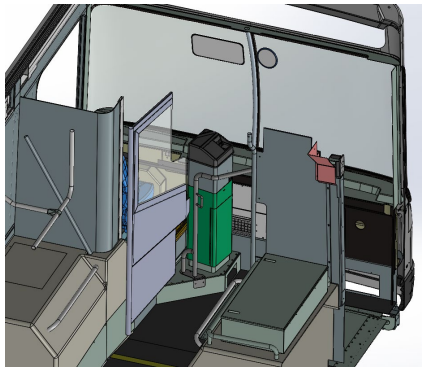
Example 1 (A)



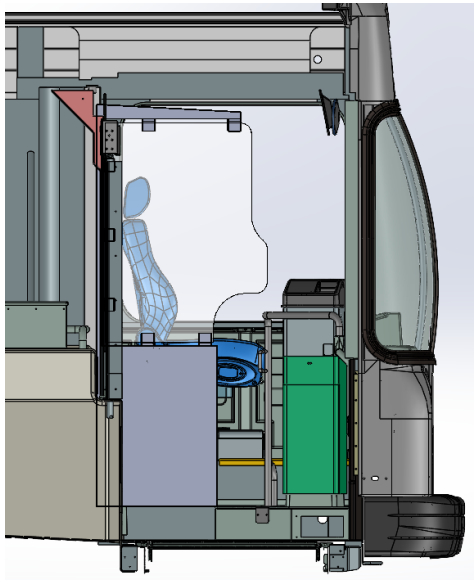


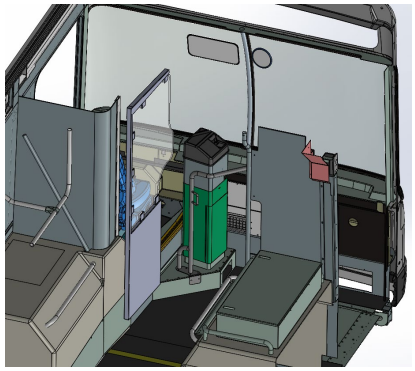
Example 2



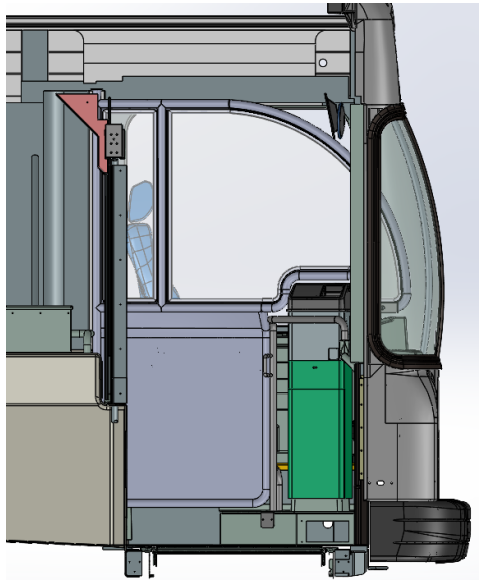


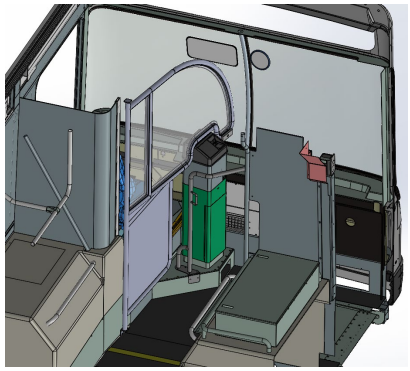
Example 3





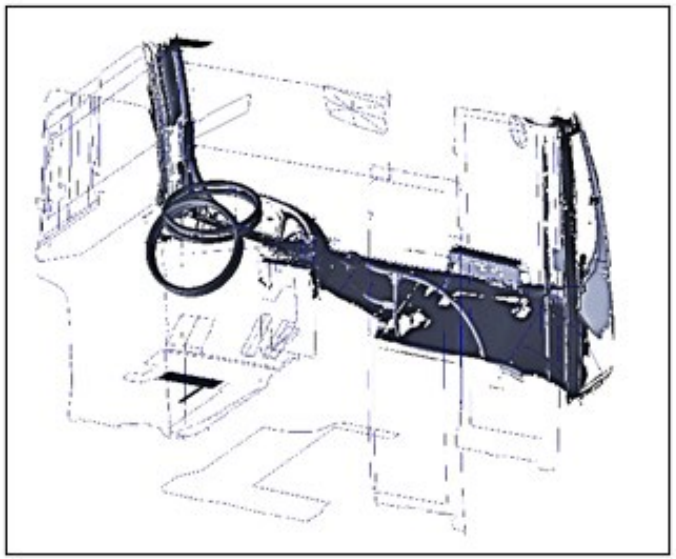
Concept (B)

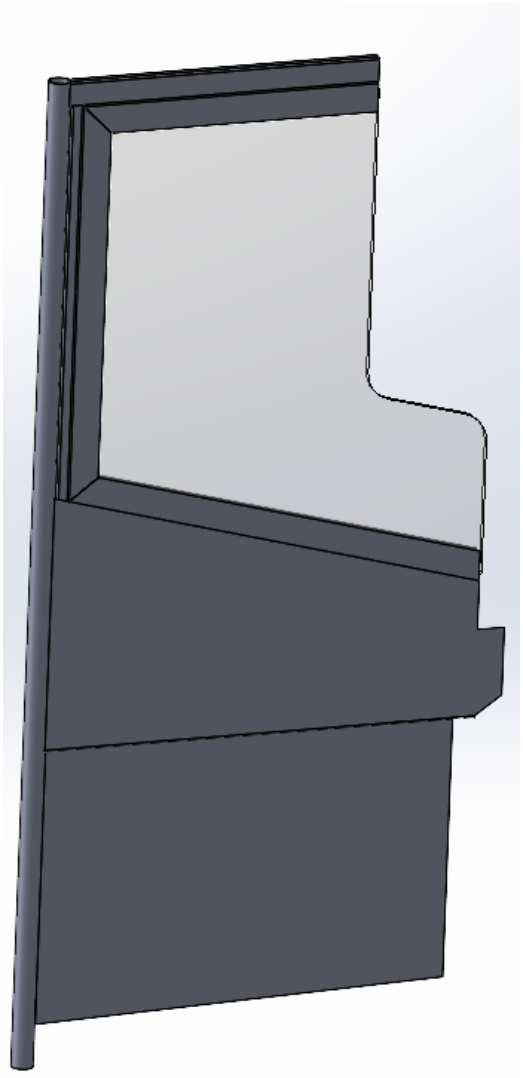




# TCRP C-25 BARRIER CONFIGURATIONS

## Configuration A: Based on data collected by VTTI on FTA NYCT Project[5]



5. https://www.transit.dot.gov/research-innovation/transit-bus-mirror-configuration-pilot-project-report-0219

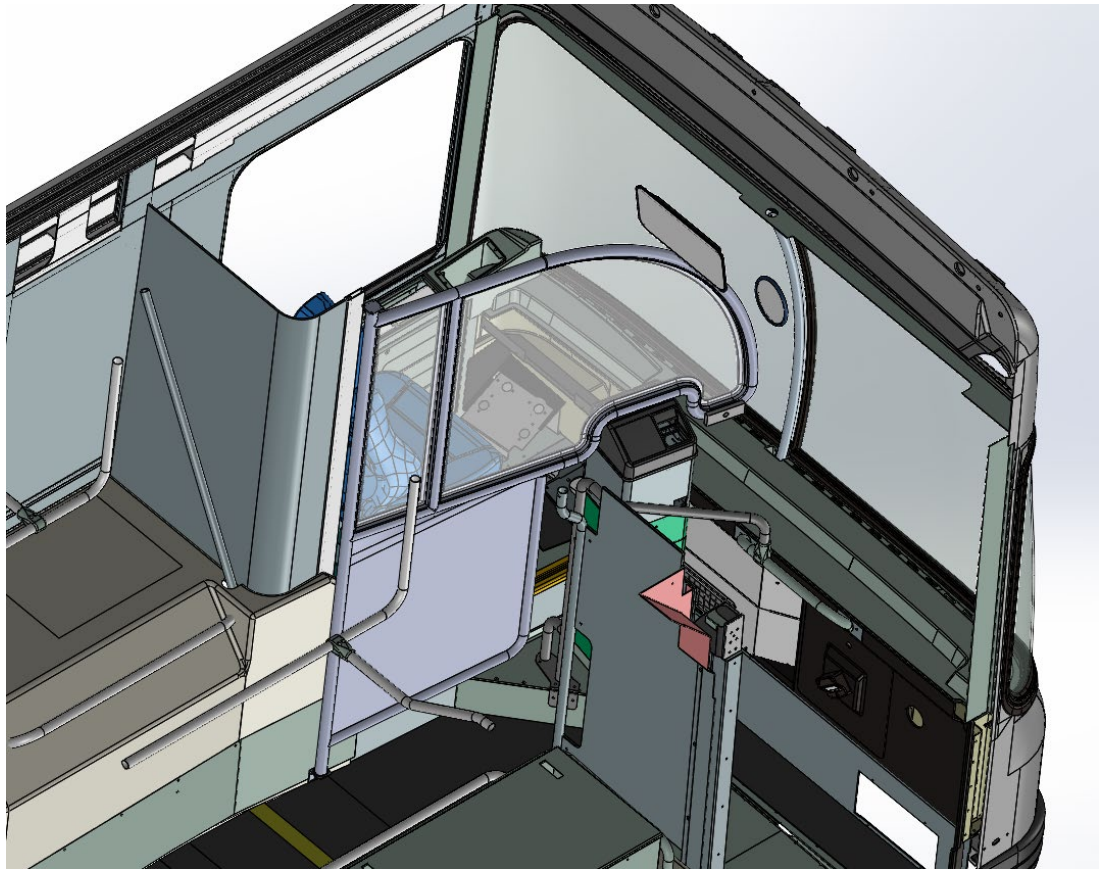
# CONFIGURATION ATTRIBUTES

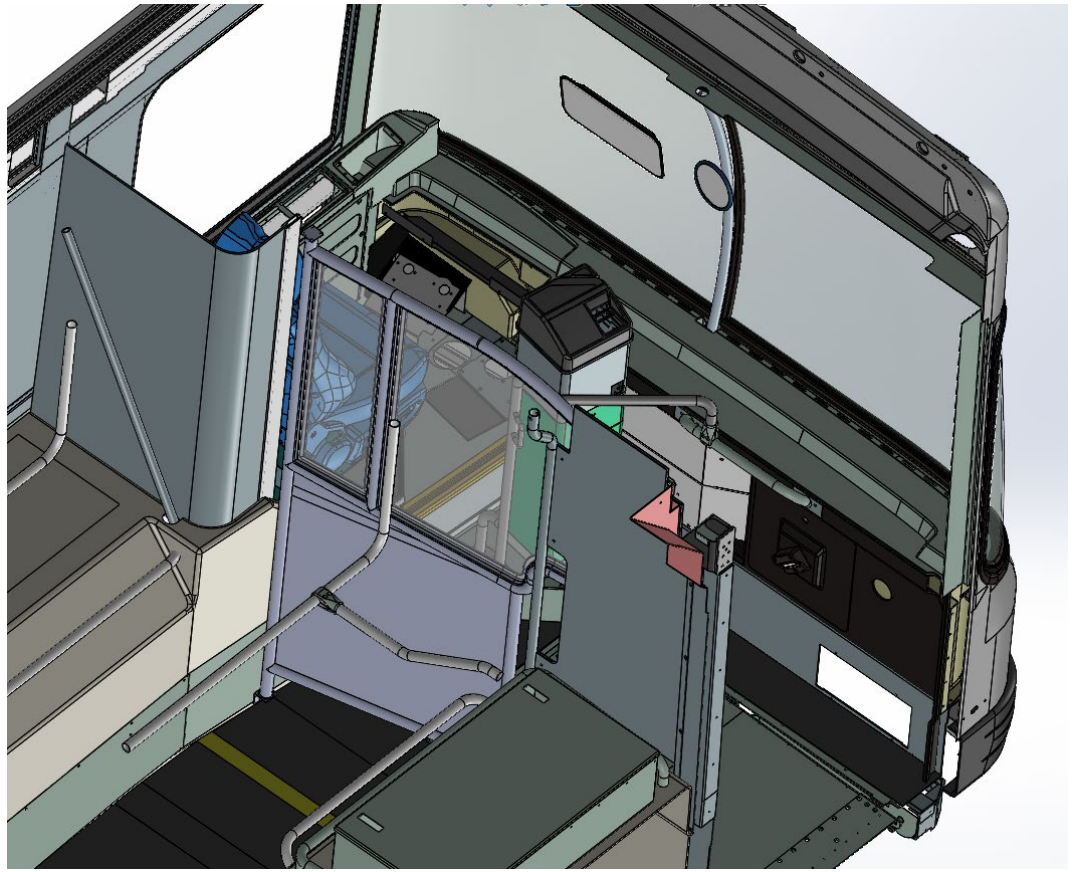
## Configuration A

- Designed as a low/moderate-cost aftermarket installation for existing buses
- Designed to **mitigate risks of physical assault** for the bus operator
- Low reduction of risks due to passenger spitting, air quality, and temperature exposure
- Maintains clearances required for front door entry of passengers with disabilities and devices
- Considers needs of bus **operator usability for manual operation** of the barrier door
- Maintains **visibility clearances of glazing** to windshield and mirrors and transparency to front entry door

# TCRP C-25 BARRIER CONFIGURATIONS

## Configuration B: Based on vehicle data provided by bus manufacturer as use case





# CONFIGURATION ATTRIBUTES

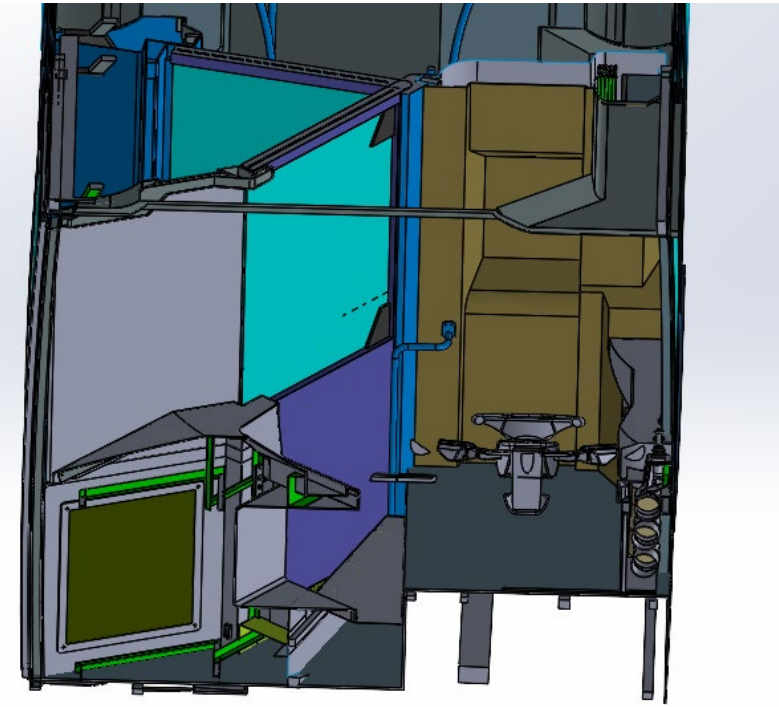
## Configuration B

- Designed as a moderate-cost aftermarket installation for existing buses
- Designed to **eliminate risks of physical assault** and mitigate spitting
- Designed to mitigate air quality and temperature risks
- Maintains clearances required for front door entry of passengers with disabilities and devices
- Design intended to provide **optimal usability with automated door** operation for **boarding and visibility** while driving for bus operators

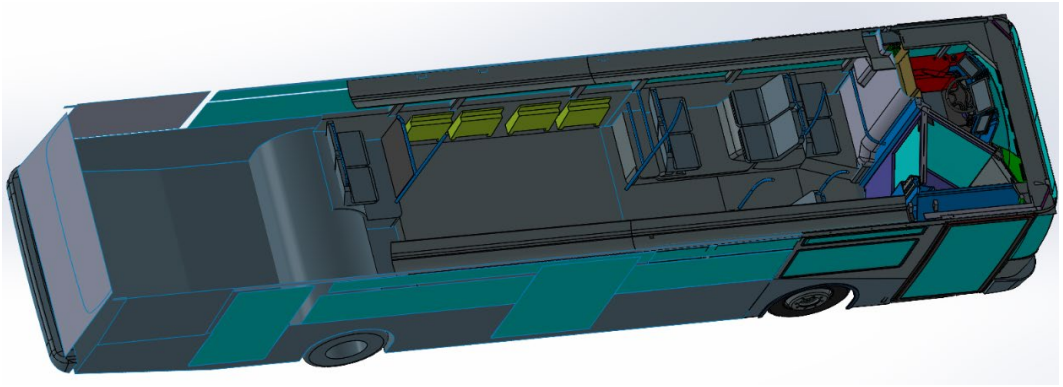
# TCRP C-25 BARRIER CONFIGURATIONS

## Configuration C: FTA "Bus of the Future"[6]

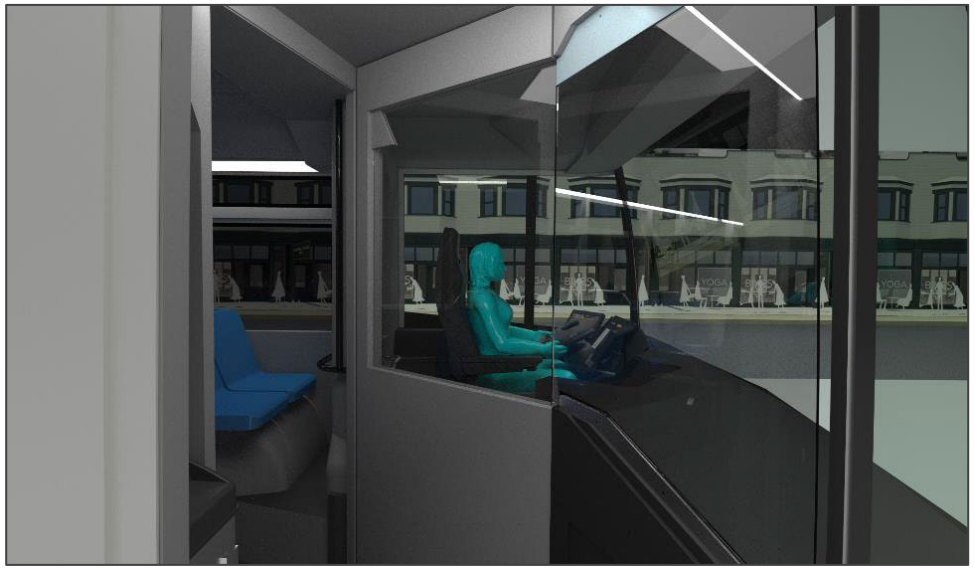
Front View (looking rearward)



Top View



Side View (rendering)



*Credit: RLS & Associates, Styl&Tech*

6. https://www.transit.dot.gov/research-innovation/bus-future-redesign-transit-bus-operator-compartment-improve-safety-operational

# CONFIGURATION ATTRIBUTES

## Configuration C

- Operator barrier designed as a fully integrated feature of newly manufactured bus
  - Offers flexibility to bus operators (they may choose whether to raise or lower the glazing); options for operator to maintain **separate air space** or provide service to passengers
  - Door could be automated to change position between boarding and driving modes.
  - Encourages middle- or rear-door entry for passengers with wheeled mobility devices
  - Glass paneling (for positive pressure isolation when glazing is raised) and thinned A- and B-pillars maximize visibility
  - **Replaces mirrors with a camera system**, removing blind spots and offering near-360 degree views around bus
- **High mitigation or elimination of all assault risks**: physical and spitting attack, air quality, temperature (assuming separate HVAC), usability for door operation, emergency egress, human factors
- **Mitigation of visibility risks depends heavily on design**; considerations include: **separate air space glass moisture/defog**, driver eye position relative to angled glazing/panels, implementation of cameras and displays

# REPORT GUIDANCE AND CONSIDERATIONS

- Configuration models provide a range of cost and risk mitigation controls
  - Configuration A: split steel/transparent glazing door; manual operation; fixed position for driving and loading
  - Configuration B: split steel/transparent glazing oversized; door automated; transitions between driving and loading
  - Configuration C: Bus of the Future bus operator compartment; door manual or automated; side/rearward visibility enhanced by cameras and displays; separate HVAC
- Concept bill of materials
- Requirement matrix organized across design criteria
- Summary of configurations, requirements, and risk mitigations

# REPORT LINK & PROJECT CONTACTS

- Report Link: https://nap.nationalacademies.org/catalog/27877/bus-operator-barrier-design-guidelines-and-considerations
- TRB/National Academies
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# Upcoming events for you

December 2-3, 2025; Denver, Colorado

How RTD and North American Transit Agencies Are Addressing Drug Use on Public Transportation

RSVP to Cheryl Webb (cheryl.webb@rtd-denver.com)

January 11-15, 2026

2026 TRB Annual Meeting

https://trb-annual-meeting.nationalacademies.org/

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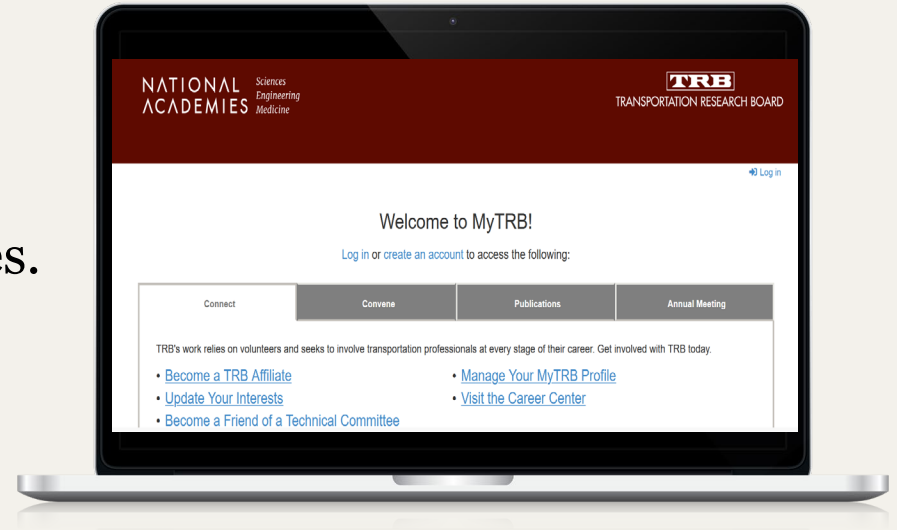


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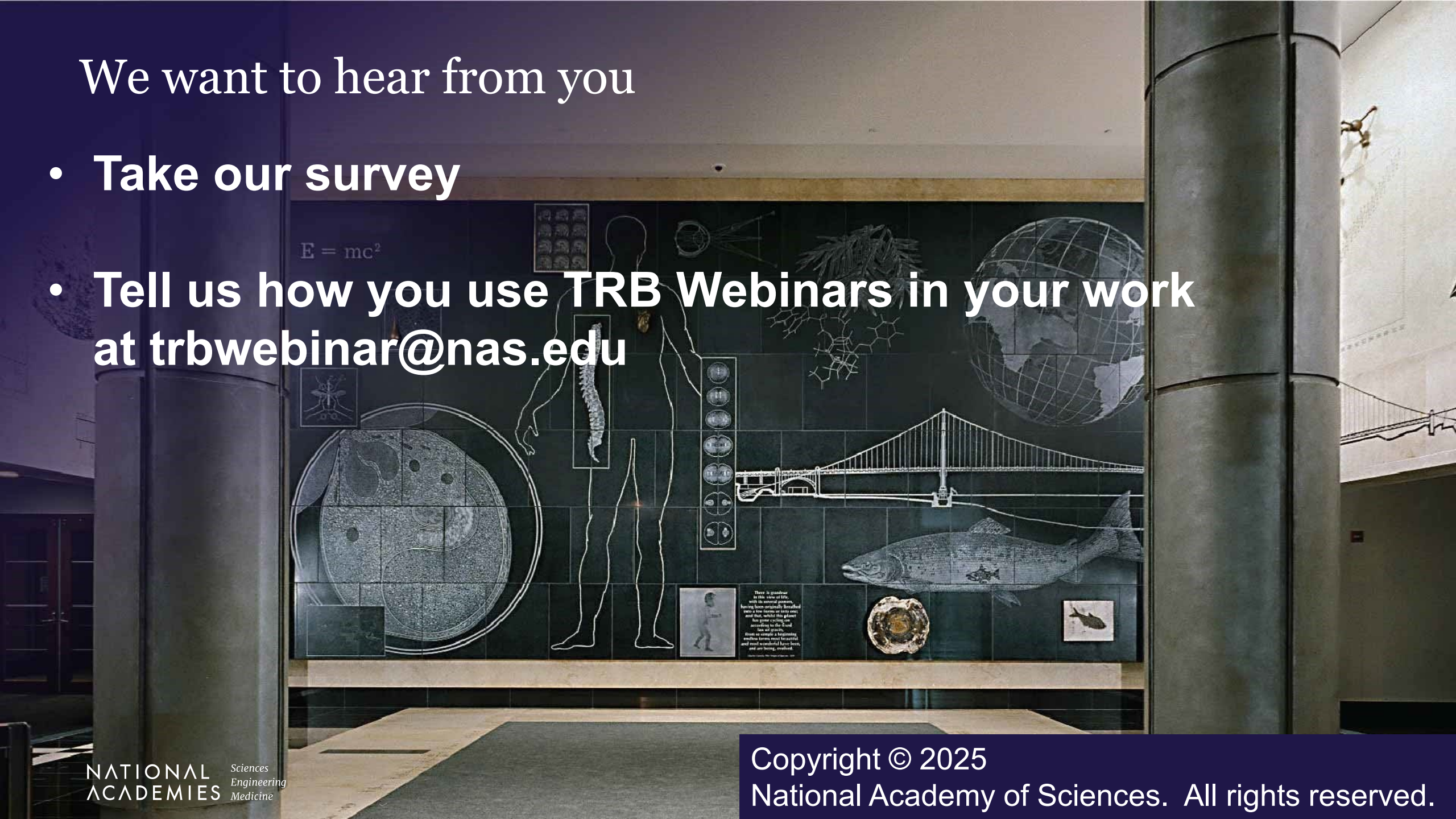


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