VIEW 2.0:
Direct Vision Assessment System

Final Report

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Summary

In 2020, on average, a pedestrian was involved in a fatal crash around every hour and a half and injured every 10 minutes[1]. VIEW 2.0 is a direct vision assessment system that visualizes the blindzone of vehicles to increase awareness of vehicle safety issues and incorporate improvements to vehicle visibility into purchasing and design decisions. Our goals for this project were to: 1. Reimagine the measurement technology to create an accurate and robust measurement method, 2. Design an intuitive user experience of the website and data collection so it supports everyday users, and 3. Increase the long-term site stability. We identified different groups of users interacting with the VIEW ecosystem to understand the various needs and goals when using VIEW. We also started off the project by exploring various measurement methods for accuracy and usability: the two existing measurement methodologies, Panoramic and Markerless, developed by the 2017-2018 SCOPE team and IIHS, respectively, and two new methods we created, LiDAR and April tags. We ultimately decided to move forward and develop LiDAR to be integrated into the VIEW 2.0 site due to its accuracy for both passenger and larger vehicles and its reproducibility. Lastly, we started improving the user experience of VIEW by identifying areas for improvement with the website and conducting user testing on both VIEW 1.0 and our redesigned site throughout the year. We delivered a redesigned public website with guided measurement and data upload processes for both everyday users and industry specialists with robust, non-specialized measurement tools.

[1] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813310

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1 - Introduction and Background

Vehicle blindzone awareness is relevant to the safety of anyone interacting with a vehicle, whether they are in the driver's seat or outside of the vehicle. There are around 6,000 pedestrian deaths and 850 bicyclist deaths in the US every year, comprising about 19 percent of all traffic fatalities. An additional 123,000 injuries to pedestrians and bicyclists are caused per year by vehicles, and these numbers are continuing to rise[2]. In 2020, on average, a pedestrian was involved in a fatal crash around every hour and a half and injured every 10 minutes[3].

Direct vision refers to anything that a driver can directly see in their field of view without the use of reflective surfaces, cameras, or similar devices, which are forms of indirect vision. The blindzone of a vehicle is the area that drivers cannot see out of directly. Even with advanced features being implemented in vehicles to allow drivers to detect hazards in the blindzone of their vehicle, improving the direct vision of a vehicle is still of critical importance. There have been several studies done to examine the difference of reaction time through direct vision, and indirect vision through a mirror or camera. Transport for London found that the reaction time of drivers is approximately 0.7 seconds faster if vulnerable road users, or VRUs, are seen through direct vision than with indirect vision[4]. Furthermore, the University of Leeds also described several key findings comparing direct and indirect vision through experiments and literature reviews[5]. While mirrors can provide information not directly visible to drivers, there are several risks such as causing distortion, being set up incorrectly, and visibility being affected by rain or dirty mirrors. Drivers are also more susceptible to overlooking reflected objects in comparison to direct objects and having less accuracy when recognizing objects in the mirror edges. The use of camera feeds displayed on an in-vehicle display also involves risks such as increased off-road glances, time to acquire critical information, and limited image resolution. Indirect vision requires drivers to think about more things at once and increases cognitive load. From the perspective of VRUs, surveys found that both pedestrians and cyclists do not trust large vehicle drivers to see them in indirect vision[6].

2 - Previous Work

In 2017, the Volpe National Transportation Systems Center and Santos Family Foundation partnered with the Franklin W. Olin College of Engineering SCOPE Capstone Program. The 2017-2018 SCOPE student team pioneered Project VIEW: Visibility in Elevated Wide Vehicles[7]. The team explored methods to calculate direct vision and created the Panoramic Method, which utilizes a smartphone camera to capture a photo of the inside of a truck from the driver's seat with a measurement pole marked at 1-ft intervals visible in the panorama photo. The team developed a website[8] to process the panoramic image, calculate visibility, and display visualizations based on an algorithm the team also

[2] https://highways.dot.gov/safety/pedestrian-bicyclist
[3] https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/813310
[4] https://content.tfl.gov.uk/road-safety-benefits-of-direct-vs-indirect-vision-in-hgv-cabs-technical.pdf
[5] https://content.tfl.gov.uk/road-safety-benefits-of-direct-vs-indirect-vision-in-hgv-cabs-summary.pdf
[6] https://content.tfl.gov.uk/road-safety-benefits-of-direct-vs-indirect-vision-in-hgv-cabs-summary.pdf
[7] https://drive.google.com/drive/u/1/folders/160kDP2nJlRUI-QY--ceCVoTeRf6gZ0kY
[8] https://blindzonecalculator.herokuapp.com/

developed. Site users could access visualizations of blind zone volume for each car and its effect on the visibility of VRUs to raise awareness of the immediacy of the safety issue for VRUs.

Since the creation of the VIEW project and webapp, the Volpe National Transportation Systems Center has partnered with the Santos Family Foundation to improve the overall experience of the VIEW system, update data validations, and optimize the website. They have been working with the US Department of Transportation, demonstrating its capabilities at conferences and for interested partners[9].

With technological advancements and new partnerships over the past 5 years, there is increased demand for a robust assessment of the VIEW methodology to improve its capabilities for accuracy, efficiency, and ease of use. Volpe has recently partnered with the Insurance Institute for Highway Safety (IIHS), where they have been working on a new approach, Markerless, to calculate blind zones of vehicles, which we evaluated as a potential methodology to carry forward into VIEW 2.0. Volpe and IIHS co-advised our SCOPE team as we validated and reinvented VIEW for more widespread use. We explored several measurement methods to calculate blind zones of vehicles and selected a new methodology to implement on the VIEW website, which is detailed in 5 - Method Decision-Making. We also evaluated the user experience of several aspects of the VIEW system, including the website, detailed in and measurement process detailed in 6.1 - Data Collection. We worked on improving the experience for several categories of users and conducted user testing to design a measurement process that is easily replicated and efficient.

3 - Our Role

VIEW 2.0 is a reinvention of the Visibility in Elevated Wide Vehicles (VIEW) system created by the 2017-2018 senior capstone (SCOPE) team at Olin College of Engineering that rates the direct vision performance of vehicles using a smartphone-based tool. We completed robust assessment of and explored new methods for data gathering and processing to increase the accuracy, ease of use, and efficiency and prepare for more widespread use of the tool. There were several key stages of the VIEW 2.0 project. First, we defined an improved and more accurate measurement system that uses LiDAR technology to calculate the blind zones of vehicles after thorough exploration and comparison of several methodologies. Alongside the methodology research process, we conducted comprehensive research and testing with interested parties and users to learn about the usability of and their experience with both the previous VIEW 1.0 system and the redesigned site. We used the insights from user testing to support our redesign decisions for both the measurement system and the website to incorporate best practices to improve the user experience engaging with the VIEW 2.0 ecosystem.

4 - VIEW Use Cases

We identified three possible categories of users who will be interacting with the VIEW 2.0 ecosystem through background research, a UX strategy workshop, and interviews. For specific users,

[9] https://drive.google.com/file/d/1Cmdf1n4k8y64vuLaQOgxRYUYCR5sRGsu/view?usp=drive_link

goals, needs and wants, and touchpoints with frequency, see Appendix L – VIEW Ecosystem user goals, needs, interactions.

Power users (Category 1): People who prioritize precise data from high-volume measurement, even if the system has a higher barrier of entry. They will be using VIEW 2.0 to access measurement instructions, upload data, and use the eraser tool to process the LiDAR scan. To support their needs, we want to design a measurement process with high accuracy blindzone calculations. Ex. Volpe, IIHS

Non-power users (Category 2): People who want an accessible tool for low-volume measurement, such as for taking measurements of an existing fleet of vehicle(s). They may take their own vehicle measurements and scans, or they will partner with power users to measure vehicles. To support their needs, we want to prioritize a measurement process that can be done without specialized tools and with minimal effort. Ex. City of Boston, NTSB

Data users (Category 3): People who access the dataset generated by VIEW but do not take measurements themselves. The data they view could be through the VIEW 2.0 site, or on a separate site. These people may be new visitors to the site and do not have much knowledge about vehicle blindzone safety. We want our site to be easily navigable with relevant information for users to easily comprehend the information presented. Ex. Safety advocacy groups, reporters

Alignment on these categories of user groups between interested parties and our team helped us define a UX strategy with the vision experience goals, tracking progress on how we are meeting those goals, and create plans to reach the future state of the VIEW ecosystem's user experience. Our new VIEW 2.0 ecosystem was designed to meet the needs of all three categories with an intuitive website interface and accurate yet easily replicable measurement process.

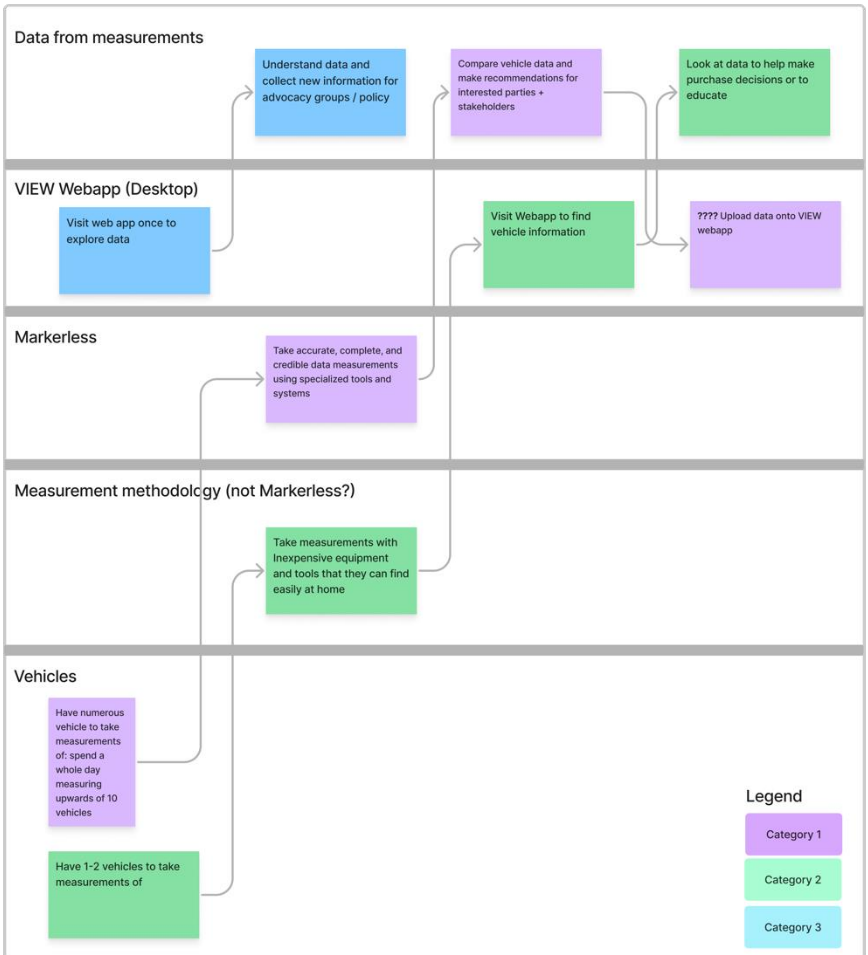


Figure 1: *Flow chart to identify touchpoints with the VIEW ecosystem for the 3 categories of users.*

5 - Method Decision-Making

In our first semester, we decided to explore the problem space. We looked into the VIEW 1.0 panoramic method and the IIHS's markerless method, both outlined above, and retested and updated an old method that the 2017-18 SCOPE team attempted, which was based on LiDAR, with the hope that the technology improved enough to make the method viable. Finally, we compared the accuracy and usability of these methods to determine the method we would move forward with.

5.1 - The LiDAR Method

The goal of the LiDAR method is to use a LiDAR sensor to generate a 3D model of the exterior of the vehicle and to use that model to inform blindzone calculations. LiDAR sensors are sensors which can determine the distance to an object by emitting a pulse of light and measuring the amount of time it takes for the pulse to return. These sensors come installed on iPhone Pro models (versions 12 and up) and iPad Pro models (versions 4 and up).

We found a third-party app called Polycam which was able to take advantage of this sensor, along with visual information from the camera and the motion data from the accelerometer to create a

3D model of an object. This model is represented as a mesh, which can be thought of as a pair of matrices. The first matrix is an n-by-3 matrix of floating-point values holding the 3-dimensional coordinates of every vertex of the mesh. The second matrix is an m-by-3 matrix of indices, where each row of the matrix defines a triangle, the vertices of which are given by indexing the elements of the row into the vertex matrix. In short, the first matrix defines a point cloud, and the second matrix defines the faces of the mesh using the vertices of the point cloud.

Given this mesh object, we use a python library called Trimesh to aid us in our blindzone calculations. Trimesh provides tools for ray casting, which allows us to send a ray from one point in a given direction and calculate if/where that ray intersects the mesh. By casting a lot of rays starting from the eye position of a driver in the car in the direction of the windshield and windows, we can determine which points on the ground the driver can see and which they cannot (see Appendix E – Measurement Methodology Decision for a description of how we determine the eye position). Specifically, for each yaw around the driver eye, we send out rays starting just below straight ahead until just above straight down (-1 to 85 degrees). Of these rays, we find the highest ray that intersects the car. This is the boundary between the blindzone and what the driver can see at that yaw. We repeat this process for each yaw from –20 to 200 degrees to approximate the blindzone around the car.

5.2 - Method Decision

We determined that accuracy would be the primary determiner of which method we would use. To measure the accuracy of these methods, we took "ground truth" measurements of the blindzone of a 2011 Honda Odyssey. To do this, we set up a phone in the passenger seat of the car, using a rig to hold the phone camera at the eye position of the driver. We then used a video stream from this phone to find the boundary of the blindzone on a 20 ft by 30 ft tarp we marked a 1 ft grid onto. From these points, we calculated the actual area of the blindzone around the car. We then compared this to the area as determined by the VIEW 1.0 panoramic method, IIHS's markerless method, and the new LiDAR method. The results are summarized in the table and plot below.

Method	Shadow Area (sq. ft)	Percent Error
Ground Truth	530.8	----
VIEW 1.0	710.8	33.9%
Markerless	454.5	-14.4%
LiDAR	556.0	4.8%

Table 1: *A summary of the accuracy of the three methods explored, in comparison to ground truth.*

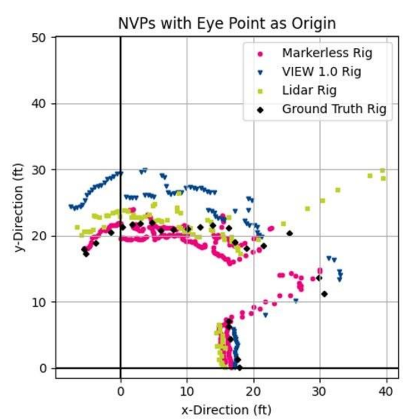


Figure 2: *A comparison of the three measurement methodologies: VIEW 1.0, Markerless, and LiDAR, to ground truth.*

However, our final decision was not solely based on the accuracy of the method. We ranked each method within the twelve criteria. We also ranked the importance of each of these criteria from the point of view of each of our three categories of users. From these rankings, we made a decision matrix from the point of view of each user. For the full data on the criteria, the rankings, and the decision matrices, see Appendix E – Measurement Methodology Decision. The final results of each matrix are summarized in Table 2. For every user category, LiDAR ranks the highest, and so that is the method we decided to move forward with.

	VIEW 1.0	Markerless	LiDAR
Category 1	64	67	88
Category 2	69	63	76
Category 3	65	74	77

Table 2: *Output of decision matrix for each user category*

6- Walkthrough of User Experience

6.1 - Data Collection

For VIEW 2.0, we simplified and standardized the data collection process to reduce user error and produce results that could be used to compare vehicles to each other. VIEW 2.0 measurement instructions are embedded on our website and are also available to download as a PDF for easy mobile access.

6.1.1 - Measurement Process

The measurement process is broken up into three main parts: gathering vehicle information, taking seat measurements, and scanning the vehicle. First, users gather general information about their vehicle to help us sort scans by vehicle. We ask for the vehicle's make, model, and year, as well as the body and weight classes. Collecting vehicle information can be confusing for users since body/weight classes can be difficult to find and model years do not always match up with the year the vehicle is manufactured. During the development process, we had a choice between asking users to provide this information or requesting a vehicle identification number (VIN) and using a VIN lookup to fill in the correct information. Since all vehicle information submitted to the site is stored permanently and we were not comfortable storing VINs on the site, we chose to have users submit the information themselves. We provided notes to explain vehicle classes and model year, as well as linking to more resources about classes. When uploading data, weight class ‘Class 1’ is suggested for passenger vehicles, although with EVs being heavier than ICE cars, passenger vehicles may start to exceed the standard limits of ‘Class 1’ vehicles. In the future, the data upload process could be revised to accept and pass VIN numbers directly to a lookup and store the results rather than the VINs themselves, simplifying the data collection process for users.

Once users have gathered general information about their vehicle, they are asked to take measurements to find the bounds of driver’s seat movement. The ‘Measure Vehicle’ section of the instructions provides a step-by-step guide for each measurement, with diagrams and photos to help users visualize the measurements they need to take.

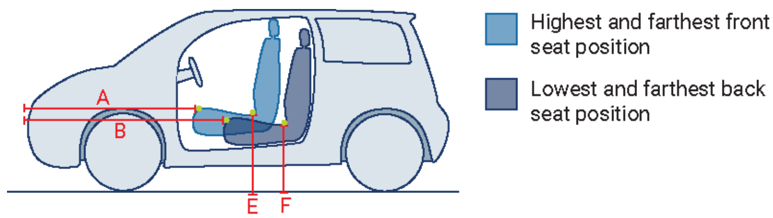


Figure 3: Seat position overview diagram.

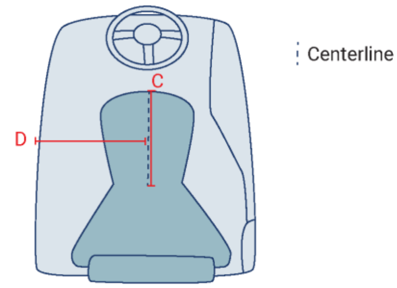


Figure 4: Eye point positioning diagram.

We collect six measurements, shown figures Figure **3:** Seat position overview diagram and Figure **4:** Eye point positioning diagram: (A) the distance from the front of the vehicle to the front of the seat at its highest and forward-most position, (B) the distance from the front of the vehicle to the front of the seat at its lowest and rear-most position, (C) seat depth, (D) the distance from the center of the seat to the outermost point of the vehicle, (E) the height of the seat from the ground at its highest position, and (F) the height of the seat from the ground at its lowest position. A, B, E, and F are used to find the bounds of seat movement, forming a virtual bounding box with extremes at each corner. Measurement C is used as an offset for A and B to simplify the process of measuring seat location, with the system adding an offset so users can measure from the more accessible front edge of the seat. Measurement D is used to offset the driver's eye point in from the outside bounds of the vehicle. With VIEW 2.0's LiDAR measurement method, users do not measure or set an exact eye height. Instead, this is virtually added to the seat position during processing, which allows the same data upload to be used to calculate results for multiple driver heights, as shown in Figure 5.

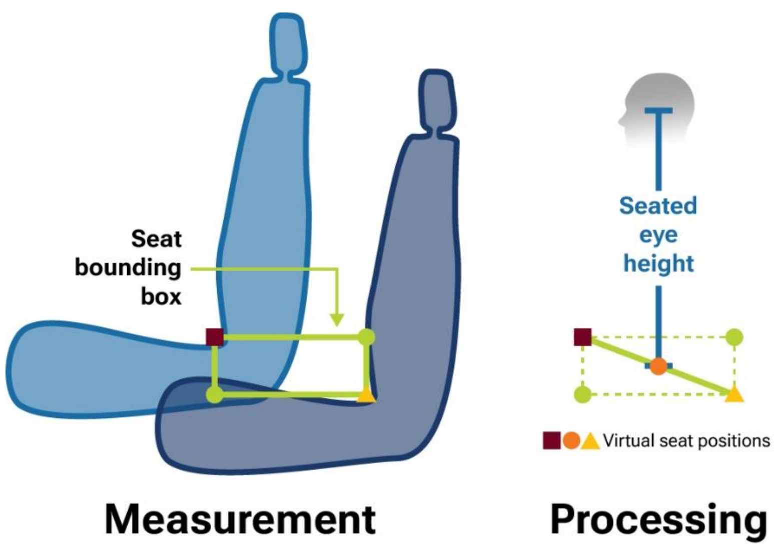


Figure 5: Seat bounds and placement diagram.

After measuring their vehicle, users move on to taking a LiDAR scan of the outside of their vehicle using the Polycam app[10] on a Pro iOS device (iPhone 12 Pro/iPad Pro 4th gen or newer) equipped with a LiDAR sensor. The 'Collect a LiDAR Scan' section of the instructions provides a step-by-step guide to starting a scan in the Polycam app, moving around the vehicle to collect a scan, and saving the file to upload to the VIEW site. Annotated screenshots point out what options to select in the app, and an example scan video shows the process of moving around the vehicle to collect data. VIEW 2.0 currently relies on Polycam, a third-party 3D scanning app. For the longevity of the blindzone calculator, it may be a good idea to explore building LiDAR scanning directly into data upload process in the future rather than relying on a third-party app that may change. During our testing, we tried scanning vehicles in Polycam using just the camera without LiDAR, a process called photogrammetry, to see if scans taken on other devices such as entry-level iPhones and Android devices would work with the blindzone calculator. We found that without the distance data from the LiDAR sensor was necessary to pick up some smooth, reflective, surfaces on vehicles, such as hoods. Without LiDAR, scans had sinks on smooth surfaces and the app had trouble stitching images together properly, as shown in Figure 6.

Figure 6: *Screenshot of photogrammetry scan with caved-in vehicle body.*

6.1.2 - Comparisons to VIEW 1.0

Compared to VIEW 1.0, the VIEW 2.0 data collection process is less reliant on custom tools, requires less space around the vehicle, and results in standardized scan data for easier comparisons between vehicles. With VIEW 1.0, users were asked to build a measurement pole to place outside of the vehicle. VIEW 2.0 makes use of off-the-shelf tools: measuring tapes, tape, and writing instruments. A selfie stick is only necessary for measuring large vehicles, something the general public are unlikely to do. The downside to VIEW 2.0 is its reliance on LiDAR, which is only found in Pro iOS devices (iPhone 12 Pro/iPad Pro 4th gen or newer). Some users may already have access to these devices, but for those who do not, the costs of acquiring one may act as a barrier to general users who want to try out the tool. Within large organizations, a one-time purchase of a device, especially if bought refurbished, should be feasible. To collect data on a vehicle with VIEW 2.0, users only need enough space to walk around the vehicle. VIEW 1.0 required vehicles to sit on a flat surface with enough space in front of the vehicle to see the ground, which could be over 10ft.

[10] https://apps.apple.com/us/app/polycam-3d-scanner-lidar-360/id1532482376

A major improvement over VIEW 1.0 is scan standardization. With VIEW 1.0, each data entry was taken at the seat position and eye height of a specific driver, preventing comparisons between vehicles submitted by different users. By collecting the full bounds of seat movement and scanning the vehicle from the outside rather than from a set eye point, VIEW 2.0 allows for adjustments to eye point during scan processing. Currently, all vehicles entered into the database are processed with the three standard eye heights used in vehicle testing (5^{th} percentile F, 50^{th} percentile M, and 95^{th} percentile M) and corresponding seat positions (high front, mid mid, and low back), allowing site viewers to select a driver height and compare blindzones across vehicles. In the future, it may be possible to allow for driver height and seat position entry when viewing blindzones, but this would require reprocessing of the data that currently takes around two minutes with our server specifications.

6.1.3 - Comparisons to IIHS 'Markerless' Method

Compared to the IIHS's 'Markerless' measurement method, VIEW 2.0 has a simpler data collection process and makes use of more accessible tools. Because of VIEW 2.0's ability to adjust seat and eye position during processing, users only need to measure the bounds of seat movement and take a single LiDAR scan. This also means that current scans can potentially be reprocessed in the future for different driver heights. With Markerless, extra tools and setup are required to find exact seat positions, and then photos must be taken with each seat position and rig height setup. By taking exact measurements of seat position and limiting how close the seat can be to the steering wheel, Markerless may have more accurate seat positioning, but for comparisons between vehicles, VIEW 2.0 provides easy-to-collect, standardized, measurements. For the purposes of standardization, both VIEW 2.0 and Markerless assume that drivers' eyes are directly above the seat and do not account for changes in height and position due to different seating positions. While this simplifies measurements (VIEW 2.0) and rig setup (Markerless), it may reduce the accuracy of results in vehicles with more reclined seating positions common in sedans.

While VIEW 2.0's requirement of a Pro iOS device with LiDAR may increase setup costs beyond that of VIEW 1.0, the tools are still more accessible than Markerless' custom measurement rig. New Pro iPhones start at $999, but refurbished models can drop to around $600, compared to the $1000+ materials cost of building the full camera rig, excluding labor. Without the option to purchase a premade rig or even build one from existing designs, sourcing the IIHS camera rig is likely unattainable for many organizations. Traveling with VIEW 2.0's measurement tools, which easily pack into luggage and pass through airport security, simplify travel for data collection.

6.2 – Website

The main interface that most, if not all, users will be interacting with is our public website at blindzonesafety.org. We redesigned the website to improve usability for our identified user groups and to implement our new LiDAR methodology for users.

6.2.1 - VIEW 2.0 Site

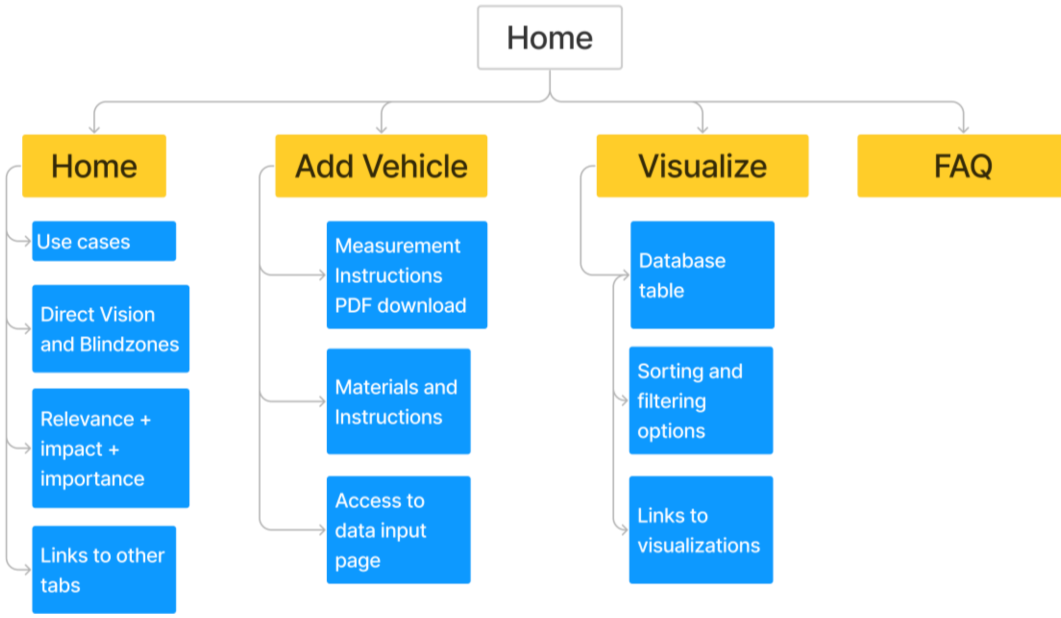


Figure 7: *Sitemap of the VIEW 2.0 website.*

The following are the main workflows and experiences our site users can take.

1. **Landing page**: The main purpose of this page is to provide information about what VIEW is, how it can be used, why vehicle blindzone safety is important, and clear call to actions for next steps to take.
2. **Measurement instructions:** On the *Add Vehicle* page, users can find the instructions to take a LiDAR scan of the vehicle and measurements to find the driver seat bounds.
3. **Upload vehicle data:** Also, on the *Add Vehicle* page are the steps to upload the vehicle information that users collected. In order to process the LiDAR scan, users need to manually remove all windows of the vehicle. We developed an eraser tool and controls to support users in this process.

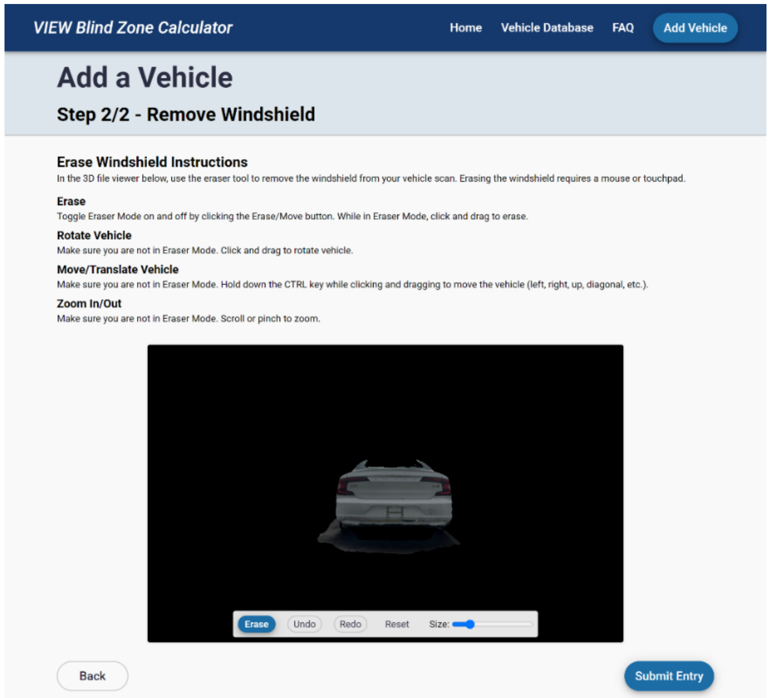


Figure 8: *Eraser controls to remove windows of the vehicle.*

4. **View visualizations:** In order to view visualizations, users will go to *Vehicle Database* which contains a table of all the vehicle entries on the site. There are various sorting and filtering functions to enable users to easily find the vehicle they are looking for. Once they go to the visualization page for the vehicle, they can choose between three driver heights and up to two VRUs to generate blindzone visualizations for. Our key focuses in improving the blindzone visualization were to design a comparison functionality for users to see the difference between blindzones for various VRUs, remove confusing wording to make it easy for users to comprehend the information displayed, and to highlight the number of users who are hidden in the blindzone.

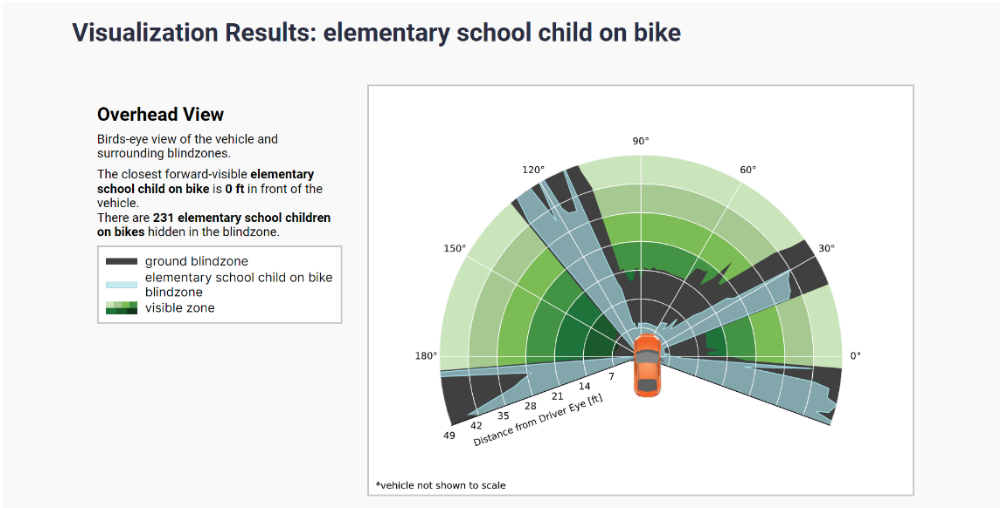


Figure 9: *Example of the blindzone visualization of an elementary school child on bike for a 50th percentile male in a 2011 Honda Odyssey.*

6.2.1 – Key User Testing Insights

To best inform our website redesign choices, we continuously met and engaged with users throughout the redesign process to receive feedback through several rounds of user tests. The full user testing plan can be found in Appendix K – User Testing Plan. First, we tested the usability and design of VIEW 1.0 to understand the areas of opportunity and pain points of navigating and comprehending the site information. We found that:

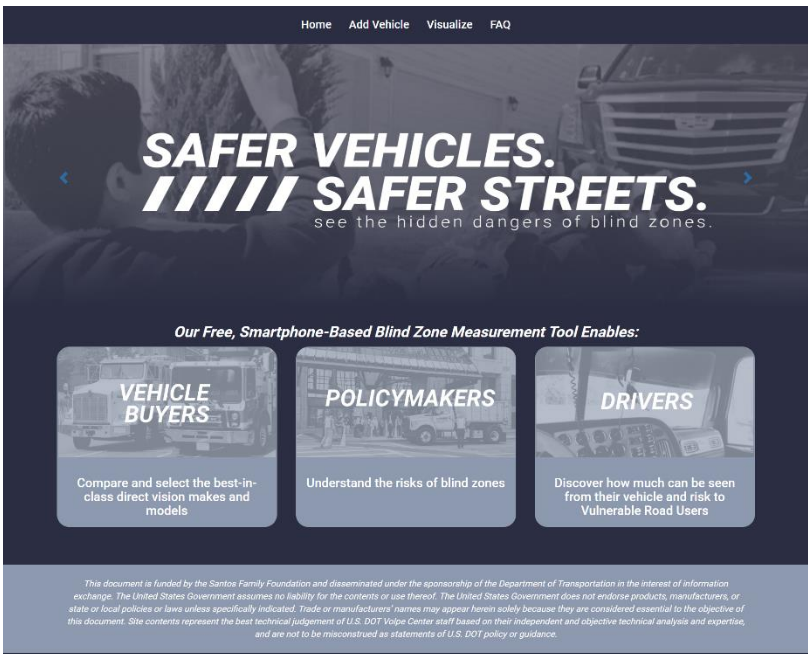
1. Users felt the View 1.0 homepage didn't clearly show the site's purpose and next steps.
2. The site is outdated and can have a more modern design and visuals.
3. Information about direct vision is key for users to care about this and should be in a more prominent place.
4. The blindzone visualizations are confusing — specifically, the 1ft scale is confusing.

We also talked to researchers who have used the VIEW 1.0 panorama method to learn about the current experience of taking vehicle measurements and uploading data. The main pain points they mentioned were:

1. Marking photos is frustrating and the controls are difficult.
2. Site is confusing to use and there is a need to make it easier to navigate, even for professionals.
3. The data analysis is unreliable and slow.
4. The tools needed for the panorama method are big and tricky to transport.

We used these insights to completely redesign the VIEW 2.0 site and measurement experience. The main changes to the site we addressed were to give users clearer information about the site purpose and tool, improve visualizations for easy understanding, design measurement instructions that enable an intuitive experience, and modernize the site visuals and brand. The findings from the VIEW 1.0 panorama method user experience helped guide our decision and design of the LiDAR method. We focused primarily on decreasing the inaccuracies of blindzone visualizations and requiring minimal specialized equipment in order to collect data.

Once we had redesigned our site, we continued to conduct user testing to help validate that we had addressed some friction areas in VIEW 1.0 that we learned during the fall interviews. We found that there was less confusion on what the site is for, actions users can take, and visualizations. Below is an example of the redesign for the previous and the new landing page. A complete site walkthrough of both VIEW 1.0 and 2.0 can be found in Appendix M – VIEW 1.0 Site Audit and Appendix N – VIEW 2.0 Site Screenshots, respectively.



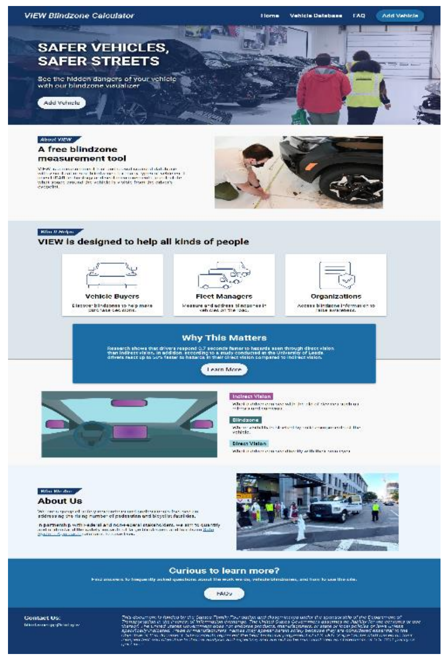


Figure 10: Comparison of the VIEW 1.0 landing page to VIEW 2.0.

7- Known Issues and Potential Extensions

Given the limitations of the SCOPE class as a 4-credit classes taken once a semester for only two semesters, there are a few bugs and inefficiencies, many additional features, and more testing of the site and measurement experience that we would have liked to accomplish. Below is a ranked list from what we deem high priority to low priority of next step tasks that could be done, with more time:

1. Memory leaks caused by the Django application failing to delete the large lidar scan mesh files after processing a scan causes a buildup of memory in the site's RAM, leading to imminent crashing of the site every second or third scan. Our current band-aid solution is to automatically start a new thread when the visualization page is refreshed and the scan thread is not running. However, this relies on the user manually restarting the thread and does not address the underlying server error. Here are some articles on potential solutions to this problem that we did not have the chance to implement:

   a. How to Solve Django Memory Link[11]
   b. Working Around Memory Leaks in your Django App[12]
2. Currently, the vehicle and raw Scan information is uploaded to the database, and the raw scan glb file is sent to the Spaces bucket before the NVP calculation algorithm is run so the algorithm can pull it from the database. This flow would be fine if the site didn't crash as is described in Item 1. However, in the case that NVP calculation does crash before finishing, the vehicle, scan, and scan file are not removed from the database and Spaces bucket in order to "wipe the slate clean." This will lead to a long-term buildup of obsolete glb files in the Spaces bucket and Scan entries in the database with no associated Completedscan entry for every crash that occurs.
   a. Either the Vehicle and Scan information should not be pushed to the database and the glb file to Object Storage until the entire process from upload to visualization is complete, or there should be a way to delete the saved entries and objects if the process fails.
3. The amount of available memory the site has is only enough to hold two, maybe three vehicle scans at a time. This means that if four users upload a scan at the same time, all four processes will crash due to memory constraints. This will happen even if issue 1 is fixed, since it will be trying to find the blindzones in all four scans simultaneously. A potential solution is to add the scans to a queue, and only process one scan off the queue at a time. In this case, displaying a message to the user about heavier than normal traffic would be a good idea.
4. The FAQ Page is currently blank and should be filled with information either from the previous VIEW 1.0 FAQs or any additional information we believe will be helpful for users to know. There is also an opportunity to conduct additional user testing to identify what information will be helpful to add to the FAQs section of the site.
5. The NVPs are currently sorted in order of angle, both for plotting and for calculating, which works well for standard blindzone boundaries, but does not suffice if the shape of the blindzone boundary is such that there are multiple NVPs along any given yaw. This would happen, for example, if there was an obstruction in the windshield where the driver could see above it and below it. The current ray casting code does not detect these kinds of shapes, but if this is expanded in the future to cover the entire windshield boundary and not just the bottom edge, the ordering of the points should be robust to these kinds of shapes for the area calculation algorithm to work.
6. There is an opportunity to expand the number of available heights to test, and/or allow a custom height feature that allows users to measure and input their own seat preference and sitting height information.
7. Right now, the database vehicle information is case-sensitive. So, if one user registers a vehicle as a KIA Seltos 2024, and another user registers the same exact car as a Kia Seltos 2024 or kia seltos 2024, the code does not recognize the case differences and update the first KIA Seltos 2024 row entry with a new scan and instead creates a new Vehicle entry. Additionally, some vehicle models include non-alphanumeric characters (i.e. Honda CR-V), which some users may omit.

[11] https://levelup.gitconnected.com/the-experience-of-solving-memory-leak-of-django-uwsgi-nginx-aws-cdb998244cfb
[12] https://adamj.eu/tech/2019/09/19/working-around-memory-leaks-in-your-django-app/

   a. A possible solution to this is to either remove the case formatting and the non-alphanumeric characters of the incoming entry and all entries in the table, so no matter what case the user types everything is compared and queried in lower case or capitalized case for example. One slight and potential downside of this is that the entries as seen in the data may not be as aesthetic to users.
   b. A second solution would be to collect the vehicle VIN number and perform a lookup and save the vehicle information without saving the VIN number. This would allow for standardized formatting across users.
8. It will be useful to conduct deeper user testing research on the new site and LiDAR measuring experience to learn about what types of visualizations are the easiest for users to comprehend blindzones with.
9. Algorithm improvements to the blindzone calculation. We may want to plot multiple boundary points for each yaw – for instance, near the base of the A pillar you may be able to see out the driver window and the windshield, so the blind zone area should reflect that. In the current algorithm, it is assumed that everything below the furthest boundary point is not visible, but this is not necessarily true. With a bit more thought, it may be possible to improve the shape of the blindzone and also reduce the number of ray casts needed. This may include a complete rethinking of how to evaluate blindzone area that may not have to be specific to a certain eye position, since we have the full vehicle scan
10. Scanning the interior of the car would allow for more accurate blindzone calculation that include things like the dashboard and rearview mirror, which can potentially be obstructive.
11. Get an image of the vehicle for its Visualization Page so users can know what the car looks like in addition to blindzone information. It is likely possible to do this automatically from the LiDAR scan by displaying the side profile of the scan.
12. Get the scaling of the car image in the blindzone plots to be accurate
13. Create a different image for the blindzone plots for different types of vehicles (i.e. a truck)
14. Update the functionality of the eraser tool to work on mobile. The challenge of this is modifying the 3D canvas to take in touch input instead of only mouse input.
15. For enhanced security, changing the login process of the Digital Ocean account to not be Google sign in, but instead inputting a username/email and password
16. Put the VIEW logo onto the navigation bar of the site
17. Additional visualizations, such as the ones created in VIEW 1.0, including visualizations from the front and side of the vehicle.
18. Because the scans include visual information of the scanned vehicles, we are effectively storing license plate numbers, which may be a privacy concern. A few potential fixes either encouraging the user to erase their license plate during the “erase windows” step, automatically finding and removing the license plate information from the scan, or erasing visual information from the scan.
19. Producing some sort of visibility “rating” for easy comparison of vehicle blindzones.

8 - Impact

This project was started because of the real and alarming issue of the increasing number of severe accidents between VRUs and vehicles. Being able to measure the blindzones of drivers in various vehicles gives us a quantifiable metric to help evaluate the safety of a vehicle for VRUs. While there is still much work to be done until outputted measurements are truly robust and reliable, it is a step in the right direction and a tool to help inform the degree to which certain car designs are limiting a driver's ability to spot VRUs while driving.

Compared to the 2017-2018 SCOPE team's VIEW 1.0, the measurement experience that we delivered is easier to understand for first-time users and more efficient for experienced users. The calculated blindzone area using the LiDAR method is 85% more accurate than when calculated using the original panoramic method. And the VIEW 2.0 site is easier for visitors of all levels of commitment to the cause to get what they want. For users who don't know anything about VIEW, the redesigned homepage succinctly and effectively explains the problem space, what VIEW is, and how VIEW will help. For users that are familiar with the importance of direct vision and want to look at vehicles to compare and purchase, the data table has become easier to query they want to measure a few cars for themselves, the measurement experience has become a lot more understandable and has more resources to help first-time measurers. And for experienced researchers and advocates in the direct vision space, the measurement experience and data upload process are much faster and simpler, enabling more vehicles to be evaluated in a shorter amount of time.

9 – Appendices

Appendix A – Blindzone Area Calculation

To calculate the area of the blindzone, we use the Shoelace formula. This is a mathematical formula that can calculate the area of a polygon given the vertices of said polygon, in order. The formula goes like this:

$$A = \frac{1}{2}\left|\sum_{i=0}^{n-1}\left(x_i y_{mod_n(i+1)}\right) - \sum_{i=0}^{n-1}\left(y_i x_{mod_n(i+1)}\right)\right|$$

Where A is the area of the polygon, n is the number of vertices, and (x_i, y_i) are the coordinates of the i -th vertex of the polygon. Note that the $mod_n(i+1)$ in the subscripts just allow the index to wrap back around to 0. Our implementation of the shoelace formula is based on a post[13] from StackOverflow in which user contributed various ways to efficiently implement the formula.

Appendix B – VIEW 2.0 GitHub Repository

Our GitHub Repository is available at https://github.com/projectview2018/VIEW2.0-site. Look at the README for reference on important files and folders, and how to get started on your computer.

Appendix C – Determining Ground Truth

In order to evaluate how well each measurement method (Panoramic/VIEW 1.0, Markerless, LiDAR) estimates the NVPs for a given driver height, real-life, measured NVP values are needed to be found at that height. And these measured NVP positions are collectively referred to as the "ground truth." Our process of collecting ground truth data is as follows:

1. We laid out a tarp of at least 20 ft. by 30 ft. And marked one short (20ft) and one long (30ft) with a sharpie marker at every foot, labeling the number of feet from our decided origin. Our process is shown in Figure 11.

[13] "Fastest Way to Shoelace Formula." *Stack Overflow*, 23 Oct. 2019, stackoverflow.com/questions/41077185/fastest-way-to-shoelace-formula/58515054#58515054

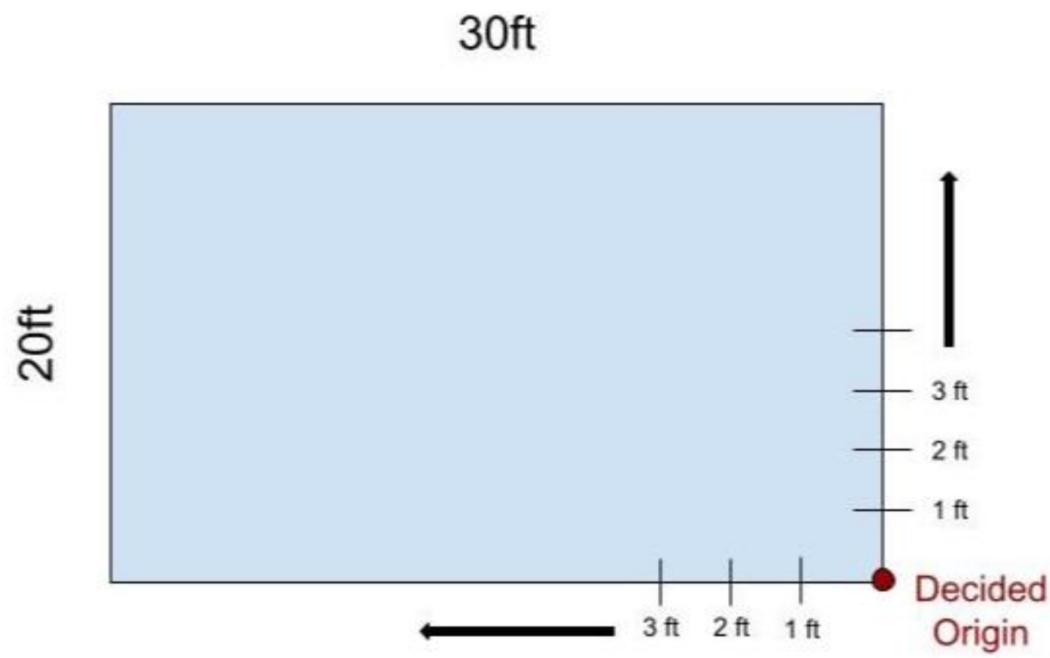


Figure 11: *Tarp layout and marking.*

2. The two remaining sides of the tarp are also marked at every 1 foot (without marking the feet, however on second trial we would have also marked these sides with numbers as it would have made drawing lines in the next step easier) such that all four sides of the tarp are marked.
3. Three people and a chalk reeler were needed to mark the lines on the grid. Two people held each end of the reeler, lining up the two ends of the reeler's chalk string to the respective foot measurements (both ends of string located at the same x position when marking vertical lines or y position when marking horizontal lines). The image below depicts the two string holders lining up the string at the 4ft x-position. Once the chalk string is aligned, a third person stands on the tarp at the middle of the string, and stretches, then releases the chalk covered string to make a line on the tarp. This process is repeated to mark the vertical lines along each y-position.
4. After creating a full grid, mark every intersection of the lines as these are our grid points, with a more permanent material like sharpie ink.
5. Drive the car over the tarp such that the driver's eye (the phone camera, be it in a rig or in a person's hands) is on the tarp and its position can be measured.
6. To measure the driver's eye position, we first located the phone camera's position relative to the edge of the car (particularly a point on the tarp tangent to the outside of the car and directly to the left of the phone camera). Mark this point, we will refer to it as Point A. From point A, measure the vertical distance of the camera from point A on the ground. Then measure the horizontal distance of the camera from point A by holding one end of the tape measure in front of the phone camera and the other to the direct edge of the car. Figure 12 shows the horizontal and vertical distances of the camera to point A and Figure 13 shows another view of the horizontal distance between the phone camera and point A.

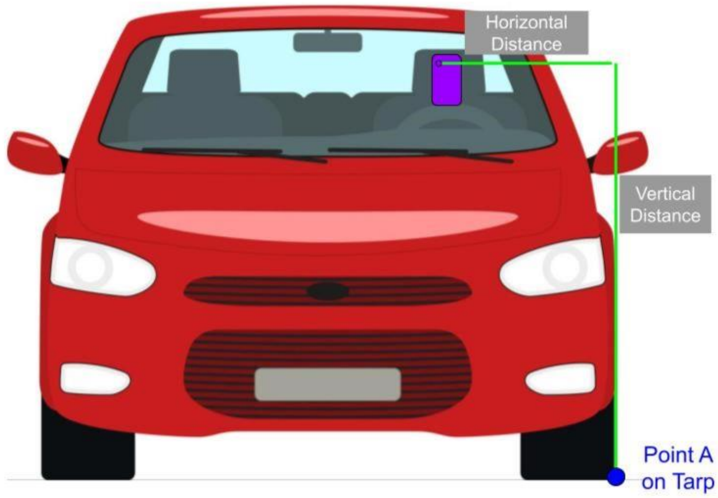


__Figure 12:__ Vehicle front view with horizontal and vertical distances of camera from point A on tarp.

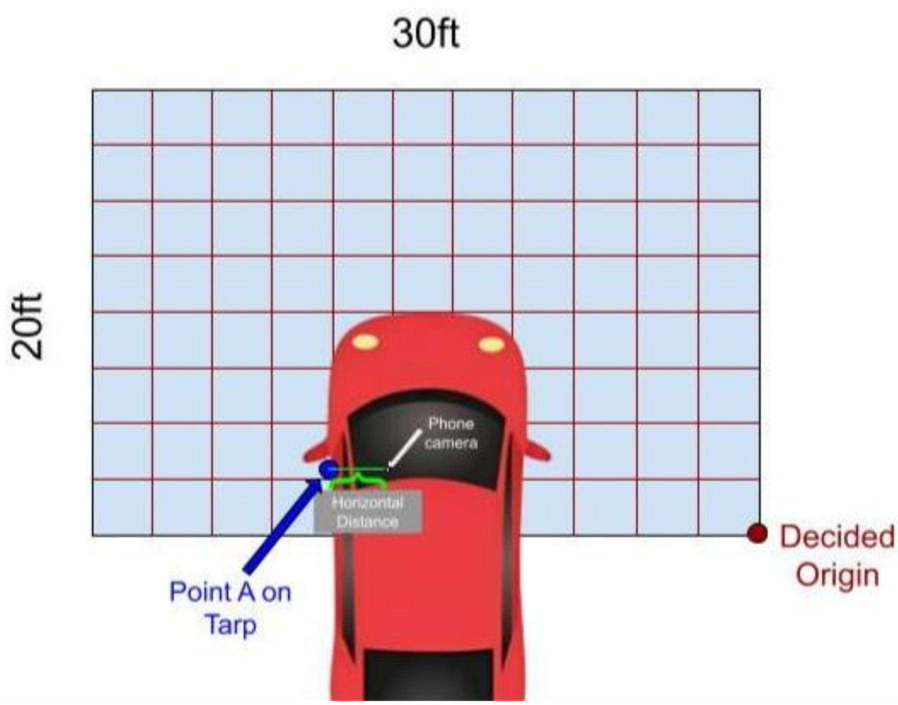


__Figure 13:__ Top-down view of tarp with horizontal distance between the phone camera and point A shown.

7. We then had one person (the eye person) sit behind the driver's seat and look through the phone camera and another person (the marker person) outside the car holding something flat and with a highly contrasting color to the tarp (our tarp was dark brown and a cream-colored clipboard was good for our purposes). We also marked the bottom of the clipboard, in the center, with a piece of bright blue tape.

8. The marker person would hold the clipboard at an angle such that the eye person could clearly see the clipboard and its blue tape, and then the eye person would tell the marker person to move the clipboard forward or backwards until the bottom of the blue tape and the clipboard are just visible. Then the marker person would place a piece of tape on the tarp along the bottom edge of the clipboard, draw a “T” symbol in the center of the blue tape with the “-” part of the symbol parallel to the clipboard, and the intersection in the symbol being the NVP. Figure 14 shows an example of marking an NVP using the clipboard. The light blue tape is the tape on the ground marked with the “T” symbol and the NVP x- and y-coordinates.
9.

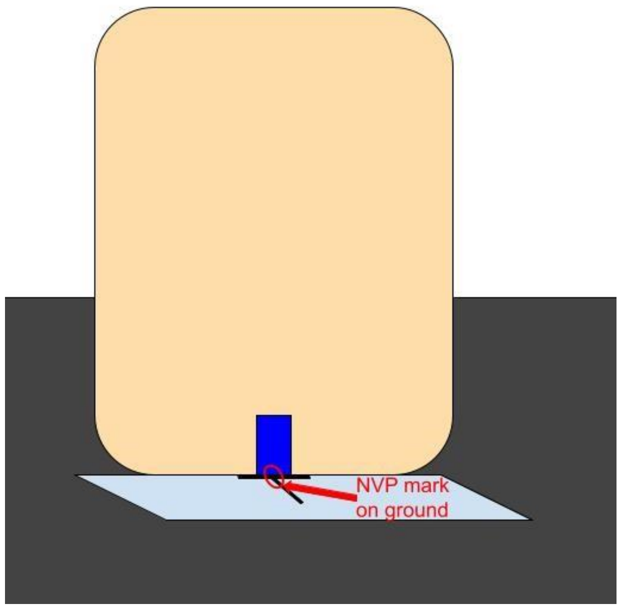


Figure 14: *Marking an NVP using a clipboard.*

9. After marking a suitable number of NVPs, we measured the x- and y-positions of these NVPS. With the help of the grid lines, we measured the x- and y-distance of each NVP to the nearest gridline to get their positions.
10. Finally, we measured the position of the driver’s eye by first finding the position of point A the same we found the NVPs, then added the horizontal distance calculated in Step 6 to find the position of the driver’s eye.
11. Then we plotted all of our points using a library like matplotlib.

Appendix D – LiDAR Method

The LiDAR methodology consists of two steps. First, a LiDAR scan is taken of the vehicle. Second, this scan is analyzed to calculate the NVPs of the vehicle from a given eye position. Note that step 1 must only be performed once, while step 2 can be done many times from different eye positions to generate different visibility results from different eye positions without the need for extra data collection.

To take a LiDAR scan, we used the Polycam app, which is (at the time of writing) available for free on the Apple App Store (although a subscription version of the app exists, it is currently not necessary to use it). Polycam uses a combination of the iPhone Pro's LiDAR with its camera and IMU to run a photogrammetry algorithm, accurately creating a 3D mesh of the object being measured. We start the scan with the phone pressed vertically against the back wheel of the car (which ensures that the axes of the resulting scan are aligned to the axes of the car). From there, we walk around the car, using the Polycam app to capture all surfaces. Note that special care should be taken to ensure that the bottom of the side of the car and the roof of the car are adequately captured. Once done, this mesh can be exported as a .glb file. From there, we can modify the mesh to manually remove any windows, leaving the rest of the vehicle mesh intact. This will be helpful for step 2.

To calculate the NVPs from the mesh, we perform ray casting. The mesh consists of two matrixes: **V** and **F**. **V** is a (v x 3) matrix, where each row gives x-, y-, and z-coordinates of a point in 3D space. **F** is a (f x 3) matrix, where each row gives three indices ranging from 0 to (v-1), inclusive. These indices are row indices of the **V** matrix, giving three points which form the corners of the face. The order of the indices does matter, as the rotation order determines which way the face is visible from. Ray casting is a function which takes in a point and a direction, and "casts a ray" from that point in that direction, noting the first time that point intersects a face. R(**x**, **d**) takes in two 3D vectors (a point **x** and a direction **d**) and returns an index from 0 to (f-1), inclusive, giving the row index of the face the corresponding ray intersects, or –1 if the ray does not intersect any face. More commonly, **R**(**X**, **D**) takes in an (n x 3) matrix of starting points, and an (n x 3) matrix of directions and returns an n-dimensional vector giving the result of R(**x**, **d**) for each row of **X** and **D**, allowing simultaneous ray casting to be performed.

To calculate the NVPs given an eye position **e**, we cast a series of rays out from -20° to 110° yaw (around the vertical axis), and from -5° to -85° pitch (around the driver/passenger axis). We perform ray casting from **e** in each of these directions to get a vector **r**, the results of all these ray casts. We reshape **r** into **R**, a (y x p) dimensional matrix, where y is the number of yaw angles and p is the number of pitch angles. We can use this matrix, along with **V** and **F**, to find the highest point on each face intersected, giving **H**, a (y x 3) matrix in which each row gives the highest point intersected by any angle with a given yaw. Since the pitch scan started at -5°, we can be sure that this is not the roof of the car, so **H** gives the highest point that cannot be seen – equivalent to the lowest point that *can* be seen. From here, **H** – **e** centers these points from the given eye position, and we can calculate the x- and y-coordinates of where these vectors would intersect the ground. These are the NVPs from eye position **e**.

LiDAR Code: *perform scan.py* in [Git repository: https://github.com/projectview2018/VIEW2.0-site](https://github.com/projectview2018/VIEW2.0-site)

Appendix E – Measurement Methodology Decision

Table 3: *Criteria weightings by user category*

Criteria	**Category 1**	**Category 2**	**Category 3**
Any phone	0.5	9	0
No rig required	0.5	10	0
No pole required	0.5	8	0
Accuracy	10	7	7
Little onboarding	0.5	9	0
Minimal setup time	0.5	9	0
Minimal car manipulation	0.5	5	0
No camera calibration	0.5	6	0
Minimal user input	0.5	3	0
Minimal computing time	0.5	5	0
Future-proof	2	7	6
Multiple eye positions	8	6	7

Table 4: *Methodology scores in each category*

Criteria	**VIEW 1.0**	**Markerless**	**LiDAR**
Any phone	10	10	2
No rig required	8	0	10
No pole required	0	10	10
Accuracy	6.5	8.5	9.5
Little onboarding	8	6	7
Minimal setup time	7	6	8
Minimal car manipulation	6	8	9
No camera calibration	10	0	10
Minimal user input	4	6	7
Minimal computing time	8	8	6
Future-proof	7	10	3
Multiple eye positions	6	4	10

Table 5: *Category 1 user's decision matrix*

Criteria	VIEW 1.0	Markerless	LiDAR
Any phone	5	5	1
No rig required	4	0	5
No pole required	0	5	5
Accuracy	65	85	95
Little onboarding	4	3	3.5
Minimal setup time	3.5	3	4
Minimal car manipulation	3	4	4.5
No camera calibration	5	0	5
Minimal user input	2	3	3.5
Minimal computing time	4	4	3
Future-proof	14	20	6
Multiple eye positions	48	32	80
SCORE	64.3	66.9	88.0

Table 6: *Category 2 user's decision matrix*

Criteria	VIEW 1.0	Markerless	LiDAR
Any phone	90	90	18
No rig required	80	0	100
No pole required	0	80	80
Accuracy	45.5	59.5	66.5
Little onboarding	72	54	63
Minimal setup time	63	54	72
Minimal car manipulation	30	40	45
No camera calibration	60	0	60
Minimal user input	12	18	21
Minimal computing time	40	40	30
Future-proof	49	70	21
Multiple eye positions	36	24	60
SCORE	68.8	63.0	75.8

Table 7: *Category 3 user's decision matrix*

Criteria	VIEW 1.0	Markerless	LiDAR
Any phone	0	0	0
No rig required	0	0	0
No pole required	0	0	0
Accuracy	45.5	59.5	66.5
Little onboarding	0	0	0
Minimal setup time	0	0	0
Minimal car manipulation	0	0	0
No camera calibration	0	0	0
Minimal user input	0	0	0
Minimal computing time	0	0	0
Future-proof	42	60	18
Multiple eye positions	42	28	70
SCORE	64.8	73.8	77.3

Appendix F – Calculating Driver's Eye Position for LiDAR

In order to calculate the position of the driver's eye in the LiDAR scan's frame and run the NVP calculation algorithm, we need two things: (1) the position of the driver's eye relative to the front left corner of the car on the ground and (2) the position of the front left corner of the car on the ground in the LiDAR scan's frame.

We need these two things because the Polycam app generates the origin of a given scan based on its own data points, and we cannot decide where that point will be. So, for each scan, we need to find the front left corner of the car inside that scan, since some of our seat measurements were taken relative to it. Below are two figures that explain the relationship between the seat measurements taken (A, B, C…) and their relationship to the front left corner of the car. In the code, referenced in Appendix B – VIEW 2.0 GitHub Repository, we developed a way to automatically find the front left corner of the car on the ground, and then we translate the driver's eye position found relative to that point, to the frame of the LiDAR scan and relative to its origin.

Depending on what side of the vehicle started the scan on (driver v. passenger) the axes of the LiDAR scan's frame change. For the driver's side, as shown in the Figures Figure **15** and Figure **16**, the positive x direction goes along the lateral axis of the vehicle to the right, and the posiitve z direction goes along the longitudinal axis of the vehicle towards the back of the vehicle. For a passenger side scan, the directions of positive x and positive z are flipped, such that positive x goes towards the left and positive z goes towards the front. The y direction for both sides is the same, with positive y pointing up and away form the ground and negative y point down towards the ground.

To find the driver's eye position relative to the front left corner of the vehicle on the ground, we use the seat measurements collected by the user. As explained in 6.1.1 - Measurement Process, A and B correspond to the seat's track bounds, C is for the approximated distance from the front of the seat to the driver's eye, D is the distance of the driver's eye to the outside of the vehicle on the driver's side, and E and F are the height bounds of the seat. We define the "front left frame" with the front left corner of the vehicle on the gorund as the origin and the axes of the LiDAR scan's frame as its axes. So, a value between A and B inclusive, plus the seat depth from C, is the z-position of the driver's eye in the front left frame. The x-position of the driver's eye in the front left frame is D. And the y-position of the driver's eye is a value between E and F, inclusive plus a driver's sitting height (when a person is sitting, the vertical distance between the top of the seat and the eye of the individual). Again, depending on whether the scan was started on the driver or passenger side, the x- and z-positions relative to the front left point can be positve or negative, for driver's side, they are positive, and for passenger's side, they would be negative.

With the x-y-z position of the driver's eye in the front left frame, some basic arithmetic is done to shift it from the front left origin to the LiDAR scan's origin and get the x-y-z position of the driver's eye in the scan's frame. Since the front left frame position is calculated using the same axes as the LiDAR scan, no rotational transformation is needed when shifting frames.

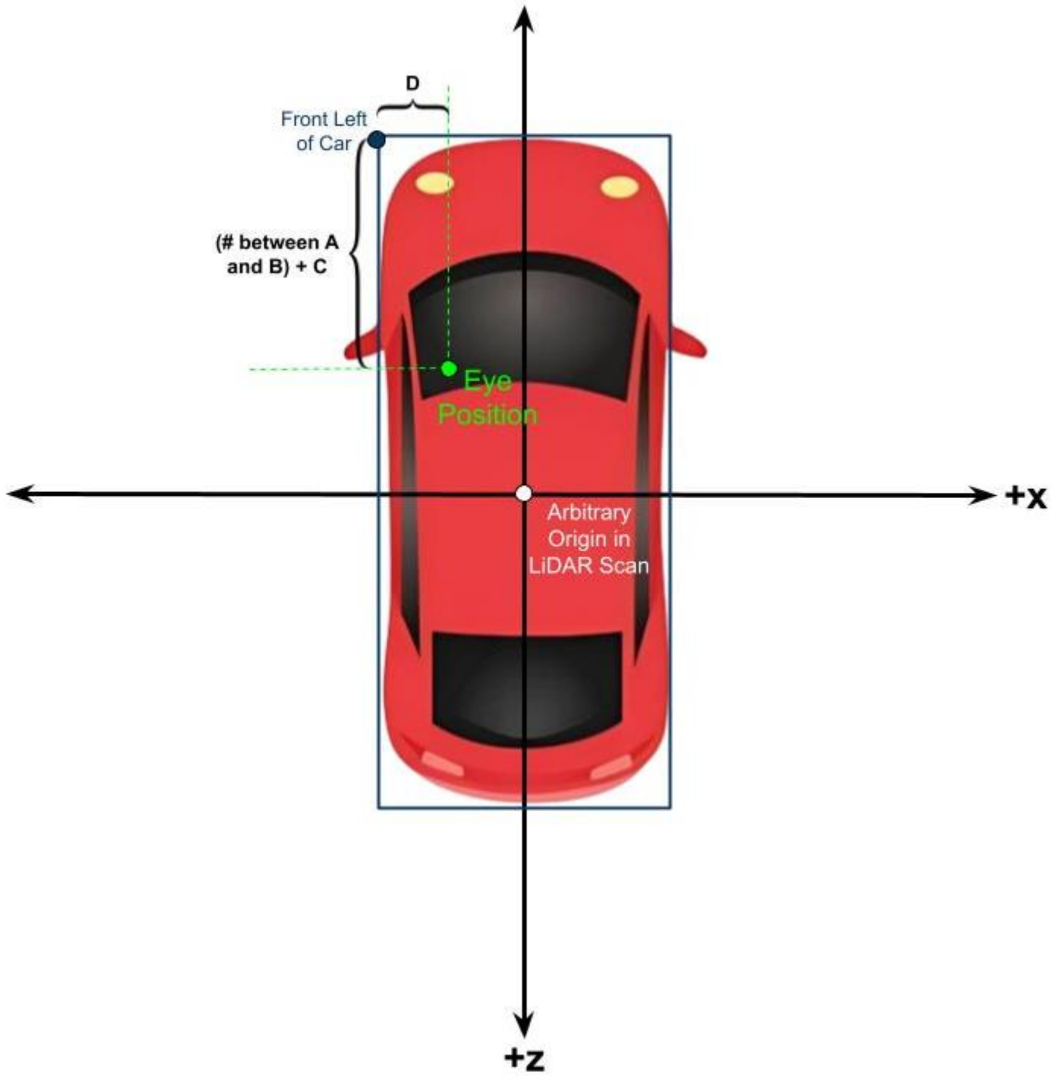


Figure 15: *Driver's eye x- and z-position explained (scan started on driver's side)*

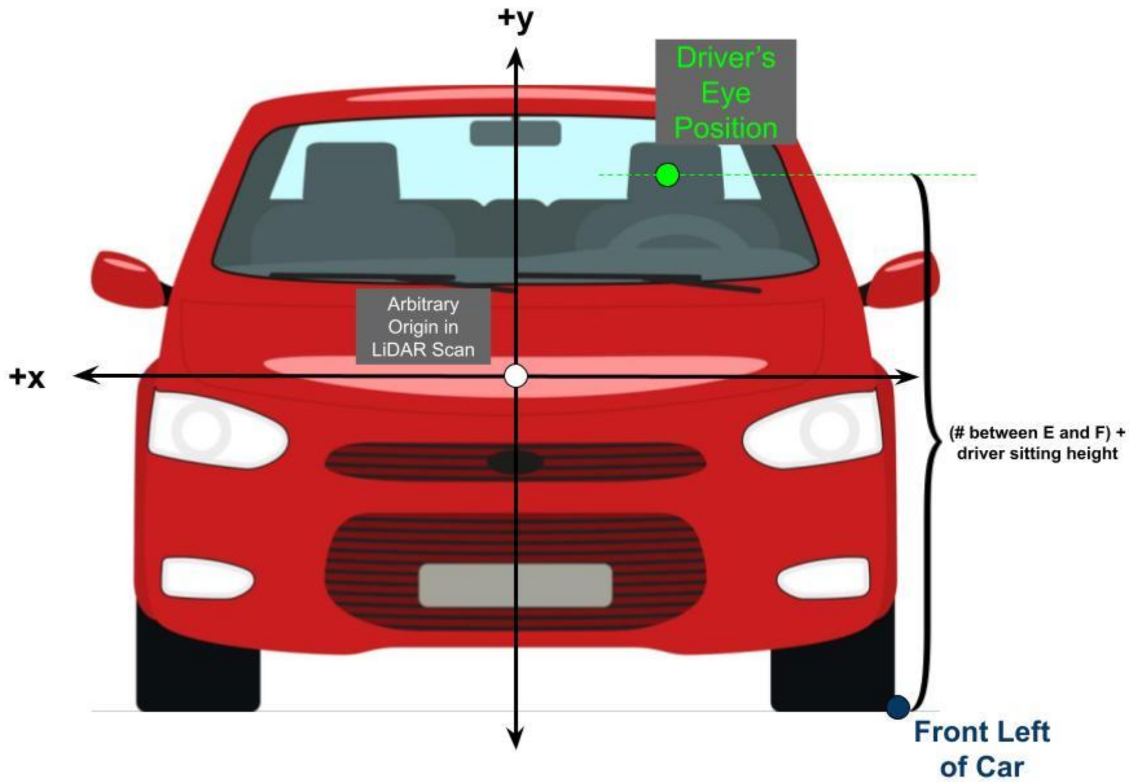


Figure 16: *Driver's eye y-position explained (scan started on driver's side)*

Appendix G - LCR-1 Fabrication and Assembly Instructions

LCR-1 Camera Rig

Fabrication and Assembly Instructions

Updated 11/30/2023

Myles Lack-Zell, Gabby Blake, Claire Hashizume, Alex Matsoukas, Benjamin Morris
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1- Tools and Materials

See 'LCR-1 BoM' for tools and materials.

2- Fabrication

2.1- Pipe Cutting

1. (optional) Practice cutting PVC pipes

Left: nice cut with 1-1.25" material on either side of blade; Right: angled cut too little material on one side of blade

It may be helpful to practice cutting pipes with the PVC pipe cutter before making any final cuts. The pipe cutter uses a rachet system that both rotates and presses a blade into the pipe with each click. Because the blade is pressing into the pipe instead of sawing through it, the PVC will separate at an angle. The resulting cut has a smooth edge but will likely be angled slightly due to the PVC splitting instead of having material removed. Cutting too close to the edge of a pipe will result in a more pronounced final edge slant due to the pipe compressing as well as splitting. We found that leaving at least 1" of material on either end of the blade produced a good enough result.

2. Measure and mark pipe lengths

Measure pipe lengths according to 'LCR-1 Technical Drawings' and mark cut lines on the pipes. Be sure to leave room to remove at least 1" from the end of the pipe before making the final cut and have at least 1" of material on either side of the cut line during final cuts.

3. Cut pipes with pipe cutter

After marking cut lines on the pipes, begin cutting the pipes to size.

4. Check pipe lengths

After each cut, check the final pipe length, measuring the shortest and longest distances. Both lengths should be within 1/16”-1/8” (~2-3mm) of the nominal size. If not, recutting the pipe or sanding/filing down to size will improve the tolerances of the final rig.

5. (optional) sand or file pipe ends

Sanding or filing the final pipe ends to be perpendicular to the pipe length will allow the pipes to sit flush against the inside of the pipe fittings and improve the overall tolerances of the rig. This step adds time and tooling to the fabrication process, and many other factors contribute to measurement inaccuracy, so we opted to skip it.

2.2- Endcap Modification

The rig is made with 3 types of customized endcaps: wheel mounts, top mount, and foot mount. The dimensions for each modification are shown in the technical drawings. Repeat the following endcap modification steps to **make 2 wheel mounts, 1 top mount, and 1 foot mount.**

2.2.1 Wheel Mounts

1. Measure and mark center

Measure the diameter of the endcap, divide in half to get the radius, and mark the center of the endcap’s top face. We tightened calipers at the radius length and scored the endcap with the tip of the tool from multiple directions to find the intersection point. A compass can be used in a similar way. The holes do not need to be perfectly centered, just visually centered, so marking the radius length should be close enough.

2. Center-punch or pilot-drill hole

Using a center punch to mark the center of the hole or drilling a small pilot hole will make alignment of the final drill bit simpler. This step is not completely necessary when using a drill press for the final holes but is important if using a handheld drill that can easily skip or slide.

3. Secure endcap

Using a vice or another method to clamp/secure the endcap before drilling will prevent the part from slipping while using large drill bits. Holding the endcap may work for a pilot hole, but the 3/4” bit used for the wheel mount is large enough to slip easily and be difficult to align.

4. Drill hole

Secure the 3/4" forstner bit in the drill and slowly drill out the hole.

2.2.2 Top Mount

1. Measure and mark center

Measure the diameter of the endcap, divide in half to get the radius, and mark the center of the endcap’s top face. We tightened calipers at the radius length and scored the endcap with the tip of the tool from multiple directions to find the intersection point. A compass can be used in a similar way. The holes do not need to be perfectly centered, just visually centered, so marking the radius length should be close enough.

2. Center-punch or pilot-drill hole

Using a center punch to mark the center of the hole or drilling a small pilot hole will make alignment of the final drill bit simpler. This step is not completely necessary when using a drill press for the final holes but is important if using a handheld drill that can easily skip or slide.

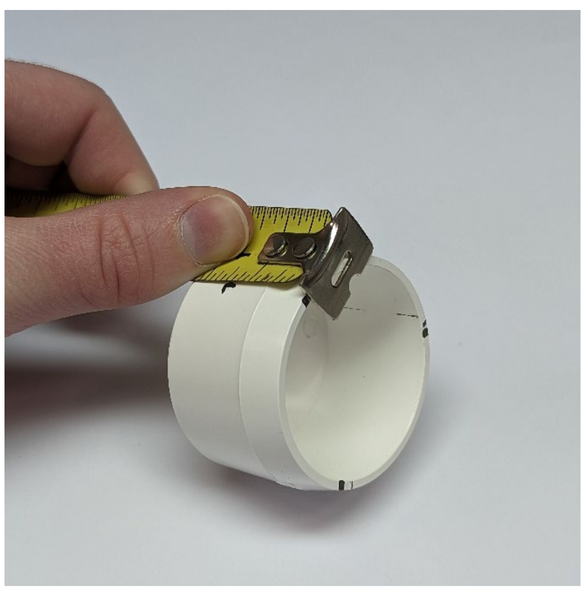
3. Secure endcap

Using a vice or another method to clamp/secure the endcap before drilling will prevent the part from slipping while using large drill bits. Holding the endcap may work for a pilot hole, but the 1/4" bit used for the top mount is large enough to slip easily and be difficult to align.

4. Drill hole

Secure the 1/4" bit in the drill and slowly drill out the hole.

5. Mark relief cuts



Mark 3 equally spaced cut lines 3/4" from the open edge of the endcap

6. Cut relief cuts

Relief cuts may be made using the PVC pipe cutter or a saw. Cutting with a saw may require trial and error to figure out how many cuts at a given depth are needed for proper fit. For each cut, hold the endcap over the pipe cutter base so the bottom of the cutter is inside the endcap and the blade is on the outside. Slowly start closing the pipe cutter until the blade is close enough to the endcap to align with the cut mark/line. Continue ratcheting the pipe cutter until it cuts through the endcap. This cut will require more force that a typical pipe cut and there may be a 'pop' as the blade goes through. Repeat until all 3 relief cuts are formed.

2.2.3 Foot Mount

1. Measure and mark hole locations

Measure out the foot mount pilot hole locations according to 'LCR-1 Technical Drawings' and mark the center of each hole.

2. (optional) Center-punch holes

Using a center punch to start each hole will reduce the chance of the bit slipping.

3. Drill holes

Secure a 7/64" or 1/8" bit in the drill and drill out each pilot hole.

4. Screw in bracket

Align the furniture foot bracket with the pilot holes and secure it with the included screws. The pilot holes will be closer to the inside edge of bracket holes than the centers. To ensure that the endcap will fit onto the foot pipe during assembly, make sure to screw the screws in straight or with the tips angled slightly in towards the center of the endcap.

3- Assembly

3.1- Wheel Base

1. Press wheel pipes into tee fitting

Press one of the two wheel pipes into each end of the tee fitting so all connections are in line with each other. Hitting the pipes in place with a rubber mallet or by pressing onto a hard surface will help the pipes to seat fully.

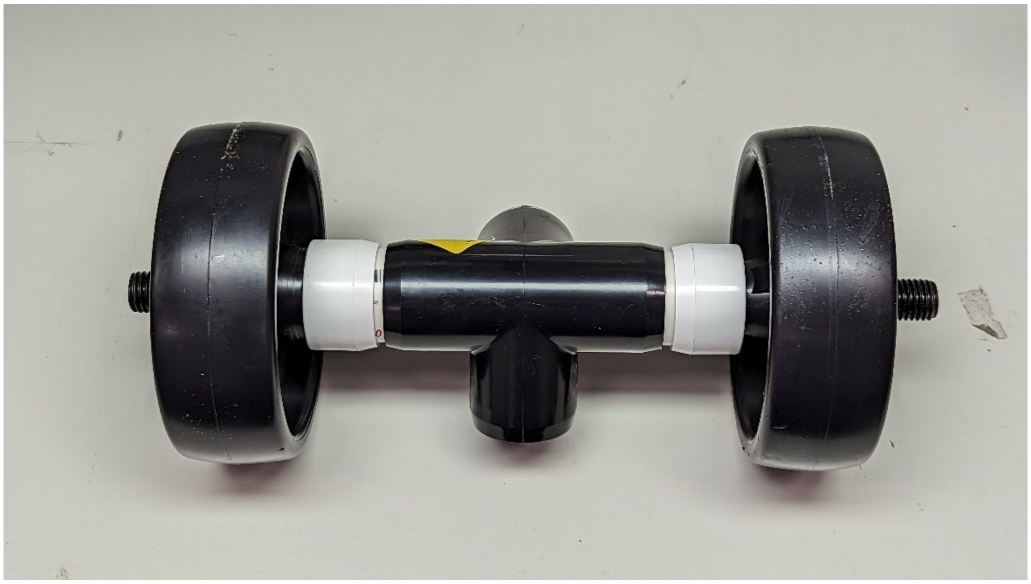
2. Press wheel mount endcaps onto wheel pipe ends

Press the wheel mount endcaps onto each exposed end of the wheel pipes. Hitting the endcaps in place with a rubber mallet will help the pipes to seat fully in the endcaps.

3. Slide threaded rod through tee fitting

Slide the 14” partially threaded rod lengthwise through the tee fitting so the threaded ends stick out from each end of the fitting. The rod should pass through both wheel pipes and endcaps.

4. *Slide wheels onto threaded rod*



Slide one of the 6” polypropylene wheels onto each end of the threaded rod.

5. *Add washers*

McMaster-Carr stocks multiple versions of the 6” polypropylene wheels, some of which have a larger bore in the hub that may cause issues with 3/4" locknuts. To mitigate this issue, add a 3/4" washer to each threaded rod after adding the wheels.

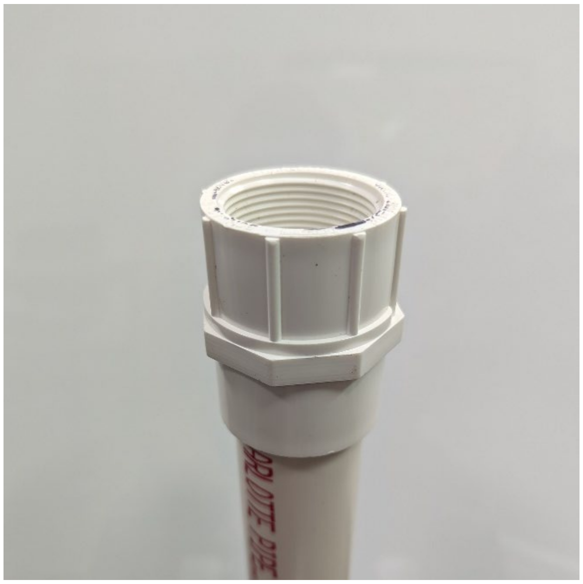
6. Secure the wheels

After ensuring that all previous components are in place, thread a 3/4" locknut onto each end of the threaded rod. Once the locknut catches, it will become difficult to turn. Keeping the threaded rod centered as well as possible along the assembly, use two wrenches and/or a wrench and vice to tighten the locknuts on each end until the wheels can no longer slide along the rod. This step may be easier to complete with two people.

7. Press torso pipe into tee fitting

Press the torso pipe into one of the exposed ends of the tee fitting. Hitting the pipe in place with a rubber mallet or by pressing onto a hard surface will help the pipe to seat fully.

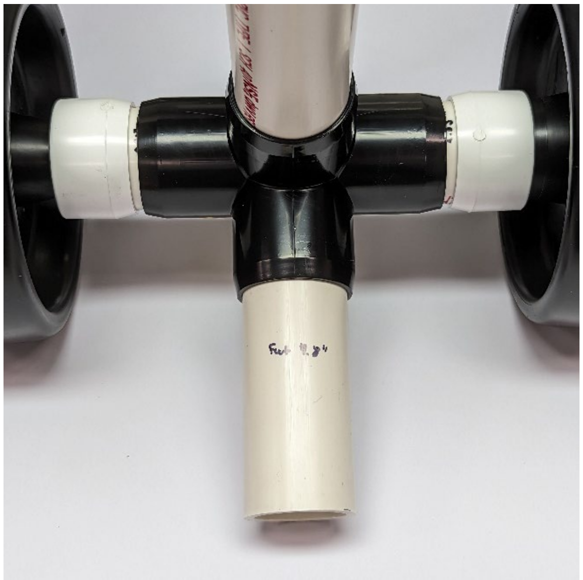
8. Press F-F PVC threaded end onto torso pipe



The female-to-female threaded PVC adapter has an internal threaded end (FPT) and a smooth ‘slip’ end. Press the slip end onto the top of the torso pipe. Hitting the adapter in place with a rubber mallet or by pressing onto a hard surface will help the pipe to seat fully.

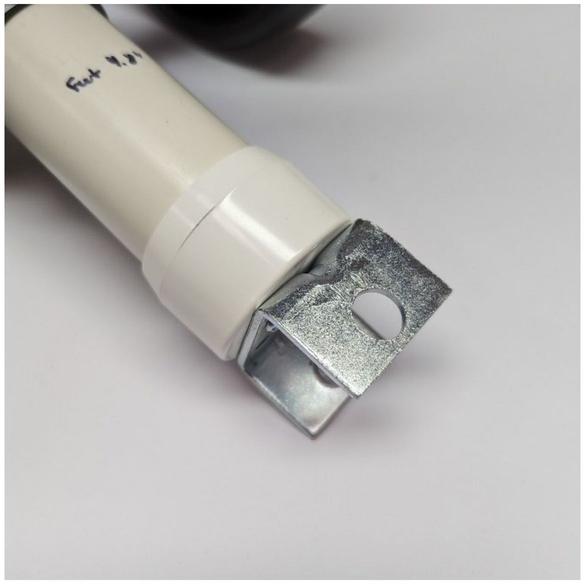
3.2- Foot

1. Press foot pipe into tee fitting



Press the torso pipe into the remaining exposed end of the tee fitting. Hitting the pipe in place with a rubber mallet or by pressing onto a hard surface will help the pipe to seat fully.

2. *Press foot mount endcap onto foot pipe*



Press the foot mount endcap onto the exposed end of the foot pipe. Rotate the endcap so the threaded side of the furniture foot bracket points down.

3. *Assemble furniture foot*

Snap the black plastic protector included in the furniture foot and bracket assembly onto the bottom of the furniture foot.

4. Screw in furniture foot

Screw the furniture foot into the furniture foot bracket from the bottom up.

3.3- Sizing Pipes and Calibration

Three sizing pipes are available to take measurements at the eye height for 5th percentile female, 50th percentile male, and 95th percentile male. **Repeat the following steps for each pipe length.**

1. Press M-F PVC threaded end onto sizing pipe

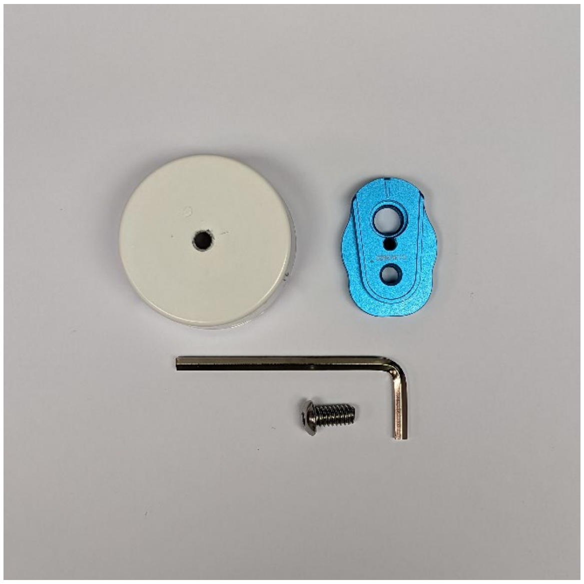
The male-to-female threaded PVC adapter has an exposed threaded end (MPT) and a smooth ‘slip’ end. Press the slip end onto one end of the sizing pipe. Hitting the adapter in place with a rubber mallet or by pressing onto a hard surface will help the pipe to seat fully.

2. Measure and mark threads

Loosely thread the sizing pipe into the torso pipe. Set a pair of calipers to 4.6” and lock in place. Adjust the pipe threading tightness until the total length of the two threaded adapters just barely fits into the 4.6” space in the calipers. Mark the external threading on the sizing pipe so you will be able to quickly thread it to this point in the future.

3.4- Top

1. Attach quick-release plate to top mount endcap



Hold the blue Kondor Mini quick release plate against the top mount endcap with the screw holes aligned and the flat surface of the plate touching the endcap (notched mount interface exposed). Using the fully threaded 1/4-20 screw included with the Kondor Blue quick release plate, screw up through the inside of the top mount endcap into the blue quick release plate. Turn the quick release plate clockwise to fully tighten the screw.

2. Press top mount endcap onto current sizing pipe

Press the top mount endcap onto the exposed end of the sizing pipe currently attached to the rig.

3. Slide a 1/4-20 3/4" machine screw through the quick release plate

Slide a 1/4-20 3/4" machine screw through gray Kondor Blue quick release plate from the inside to the flat outer surface.

4. Add a 1/4" washer to 1/4-20 screw

Slide a 1/4" lubricated nylon washer over the 1/4-20 machine screw. The washer will act as a spacer and allow for smoother rotation of the phone camera in the completed rig. The lubricated nylon washers specified in the BoM claim to fit 1/4" screws but are designed for 5/16”, so they will look large.

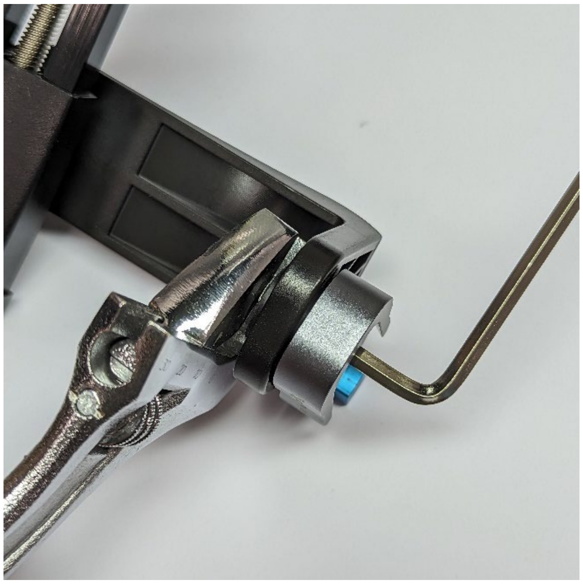
5. *Begin threading the tripod mount of the phone stand onto the 1/4-20 screw*

Start threading the bottom 1/4-20 mount of the phone stand onto the 1/4-20 screw until there is enough room to add more components.

6. *Add a rubber washer to 1/4-20 screw*

Slide the rubber washer included with the Kondor Blue quick release plate onto the 1/4-20 screw. This washer will help to hold the screw in place.

7. Secure phone mount



Thread a 1/4-20 locknut onto the 1/4-20 screw until it catches. Holding the nut with a wrench, tighten the screw using the large hex key included with the Kondor Blue quick release plate. Continue to tighten the screw until the phone mount rotates smoothly about the quick release plate but does not move vertically/shake. You may need to turn the locknut to back the screw out of the phone mount slightly while tightening.

8. Slide phone mount in place

Left: locked; Right: unlocked

If the latch on the quick release plate is locked (sticking out from the end of the plate), rotate it to unlock (sticking out from the side of the plate). Slide the gray side of the quick release onto the blue plate mounted to the top mount endcap. Lock the quick release.

Appendix H - LCR-1 Fabrication and Assembly Notes

Pipe Cutting

- Make sure to leave at least 1" of material on either side of the pipe cutter blade, otherwise the cut edge will have a severe angle to it
- I did not sand/file down the edges after cutting to make them perpendicular to the pipe length, so the tolerances on the rig are not as tight as intended

Assembly

Interchangeable Parts

I attempted to loosen the fit of the top cap by taking on and off multiple times and sanding down, but it was still too tight to remove by hand. Sanding would work if a lot of time is spent doing trial and error to get the right fit. I ended up adding relief cuts to the cap, which will likely loosen and fail over time.

Switching from a PVC coupler to threaded adapters for attaching the interchangeable sizing pipes make them removable, but the threading is taper to tighten to the point of being watertight. This results in the threading not bottoming out before being too tight to work with, and different people will be able to tighten the threading to different points. I ended up selecting an average tightness level and marking it on the threads themselves to show how much to screw in the sizing pipes, but this does not prevent someone from screwing it in further and the threads will likely loosen over time.

Furniture Foot

The leveling mount bracket might be able to be screwed straight in with the included screws, but the self-tapping plastic screws purchased will be too large for that. I'm currently using 2 of the 4 screws provided and screwed them in at an angle to make sure they don't hit the inner tube, but the bracket may need to be glued in place instead.

Wheels

PP wheels come with different hubs (the 2 we got don't match), and one version of the hub requires a washer for the locknut to not pull in/rub.

3/4" locknuts are really hard to turn, and gripping one end while turning the other sometimes tightens the one being held instead of the one being turned. It might be possible to switch to regular nuts and see how long they stay tightened.

Drilling holes

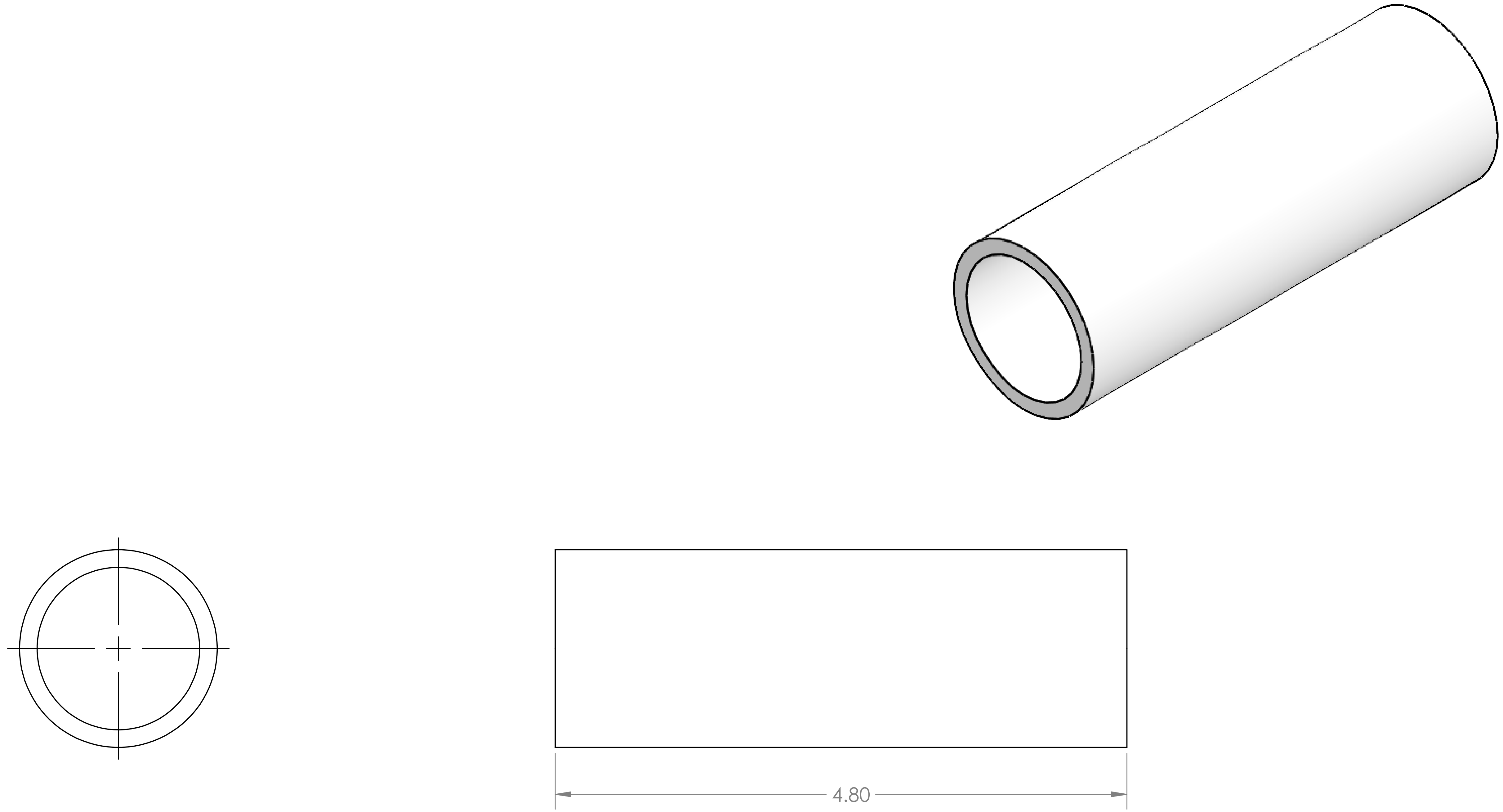
I drilled holes using a drill press but using the recommended bit type for the 3/4" hole (forstner) will allow a handheld drill to be used. A vice or something similar is needed to hold the caps in place while drilling, but a regular vice works fine (no need for a V or rubber addons to holes a cylinder).

For the 1/4-20 screw on for the phone mount, I drilled with a #7 bit on the drill press and tapped to size by hand. 13/64" is probably close enough. Taps can be expensive, so a 1/4" drill bit could work on its own but won't 'bite' into the cap. The 1/4-20 hole is centered on the top cap, which centers the clamp portion of the phone mount. The camera is therefore not centered, but every phone has a different camera placement and depth, so centering the clamp makes the most sense.

Appendix I – LCR-1 Bill of Materials (BoM)

	A	B	C	D	E	F	G	H	I	J
1	**LCR-1 Bill of Materials (BoM) - updated 11/29/2023**									
2	**Category**	**Description**	**Quantity**	**Unit Cost**	**Total Cost**	**Part/Model #**	**Vendor**	**Material**	**Link**	**Notes**
3	**Standard Tools (may not need to purchase)**									
4		Handheld drill	1	$27.63	$27.63	GD38B	Home Depot		https://www.	A low cost option in case the fabricator does not have access to a drill, but any drill will work (AC, battery, handheld, drill press)
5		Drill bit set	1	$15.97	$15.97	A98401	Home Depot		https://www.	Only a 1/4" and 1/8" or 7/64" are needed
6		Adjustable wrench	1	$13.97	$13.97	90931	Home Depot		https://www.	1 required, but 2 may be helpful. Must open at least 1-1/8"
7		Tape measure	1	$12.97	$12.97	PHV1425DN	Home Depot		https://www.	To measure and check cut lines for PVC pipe. A combination fractional/decimal (engineering) tape measure is helpful but is
8		Permanent Marker	1	$2.68	$2.68	30162PP	Home Depot		https://www.	To mark thread distance and cut lines on PVC
9		**Subtotal**			**$73.22**					
10	**Specialty Tools**									
11		2" PVC pipe cutter	1	$26.82	$26.82	16PL0805	Home Depot		https://www.	
12		3/4" forstner bit	1	$10.97	$10.97	FB-005	Home Depot		https://www.	
13		Vice	1	$32.97	$32.97	BV-CO30	Home Depot		https://www.	Can make due without as long as you have a way to secure endcaps for drilling
14		Automatic center punch	1	$11.97	$11.97	B008DXYOLC	Amazon		https://www.	Not necessary but may be helpful to have
15		Calipers	1	$25.97	$25.97	NEIKO 01407A	Amazon		https://www.	Optional. To check thicknesses and mark centerpoints
16		**Subtotal**			**$108.70**					
17	**Stock**									
18		1.25" PVC pipe (2ft)	4	$4.37	$17.48	VPC-22125	Home Depot		https://www.	We used 5 but made extra cuts
19		1.25" PVC flat end cap (10-pack)	1	$15.99	$15.99	F114EEC-WH-10	Home Depot		https://www.	4 endcaps used
20		White vinyl (3ft roll)	1	$4.49	$4.49	Cricut 2008507	Amazon		https://www.	To cover back of sewing ruler as measurement backplate
21		**Subtotal**			**$37.96**					
22	**OTS Parts (Rig)**									
23		1.25" PVC MPT to slip adapter	3	$1.76	$5.28	PVC021091200HD	Home Depot		https://www.	
24		1.25" PVC FPT to slip adapter	1	$2.24	$2.24	PVC021011200HD	Home Depot		https://www.	
25		1.25" PVC 4-way tee fitting	1	$4.26	$4.26	4824T95	McMaster		https://www.	
26		6" diam. 2" thick PP wheel	2	$6.81	$13.62	2781T57	McMaster		https://www.	McMaster supplies at least 2 different versions. The hubs/mounting holes are different sizes and a nut may partially slip into the hole on some wheels
27		3/4-10 14" threaded on both ends stud	1	$14.40	$14.40	90281A871	McMaster		https://www.	
28		3/4" washers (10-pack)	1	$6.95	$6.95	92141A056	McMaster		https://www.	Necessity dependent on wheels received. If using, only 2 are needed
29		3/4-10 high strength locknut (5-pack)	1	$6.26	$6.26	90630A135	McMaster		https://www.	2 locknuts used
30		M8 leveling mount with bracket	1	$4.79	$4.79	6943K3	McMaster		https://www.	
31		1/4-20x3/4" machine screws (50-pack)	1	$10.40	$10.40	92949A540	McMaster		https://www.	1 screw used
32		1/4-20 locknuts (100-pack)	1	$5.38	$5.38	90566A029	McMaster		https://www.	1 locknut used
33		1/4" lubricated nylon washers (5-pack)	1	$6.01	$6.01	91545A260	McMaster		https://www.	1 washer used
34		Small OD 1/4" nylon washer (25-pack)	1	$7.40	$7.40	90295A218	McMaster		https://www.	Untested; may be unnecessary
35		Kondor Blue mini quick release plate	1	$24.99	$24.99	QR_ECO_PARENT	Amazon		https://www.	Can make due without
36		Phone mount	1	$7.49	$7.49	B07S8TTH34	Amazon		https://www.	When lining up the phone camera with the mount, phones only fit upside-down
37		**Subtotal**			**$119.47**					
38	**OTS Parts (Measurement)**									
39		20lbs ankle weight set (each 10lbs)	1	$20.49	$20.49	HHA-CB020A1	Amazon		https://www.	Use 1 ankle weight (10lbs)
40		1/4-20 ball head pedestal mount	1	$12.95	$12.95	2324-US	Amazon		https://www.	
41		Kondor Blue mini quick release plate	1	$24.99	$24.99	QR_ECO_PARENT	Amazon		https://www.	can make due without
42		Bosch laser measure w/ inclinometer	1	$169.00	$169.00	GLM-165-27CGL	Amazon		https://www.	A version w/o Bluetooth exists and may be available at a lower price if it has not been discontinued
43		Sewing ruler (6x18)	1	$16.95	$16.95	108560-618	Amazon		https://www.	
44		Sign base (3" black 10-pack)	1	$11.99	$11.99	N/A	Amazon		https://www.	Not very stable, so finding a better alternative would be helpful
45		**Subtotal**			**$256.37**					
46	**Custom Parts (Rig)**									
47		Wheel pipe	2				In-House	1.25" PVC pipe		
48		Foot pipe	1				In-House	1.25" PVC pipe		
49		Torso pipe	1				In-House	1.25" PVC pipe		
50		5th F pipe	1				In-House	1.25" PVC pipe		
51		50th M pipe	1				In-House	1.25" PVC pipe		
52		95th M pipe	1				In-House	1.25" PVC pipe		
53		Wheel support cap	2				In-House	1.25" PVC endcap		
54		Foot mount cap	1				In-House	1.25" PVC endcap		
55		Top mount cap	1				In-House	1.25" PVC endcap		
56	**Total Cost**				**$595.72**					
57	**Total Materials Cost (w/o tools)**				**$413.80**					

Appendix J – LCR-1 Technical Drawings



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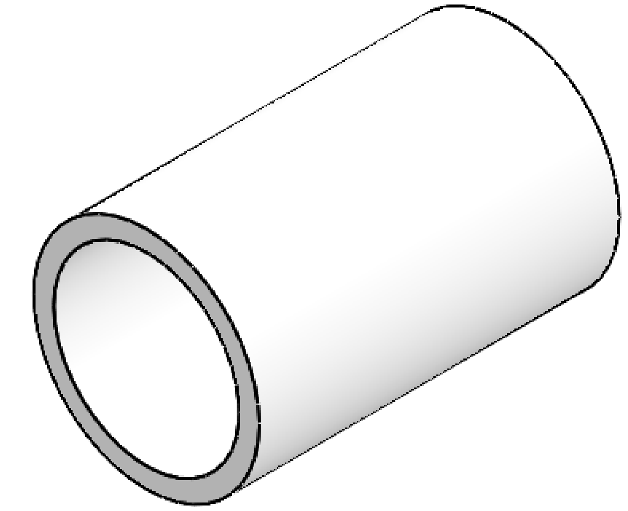
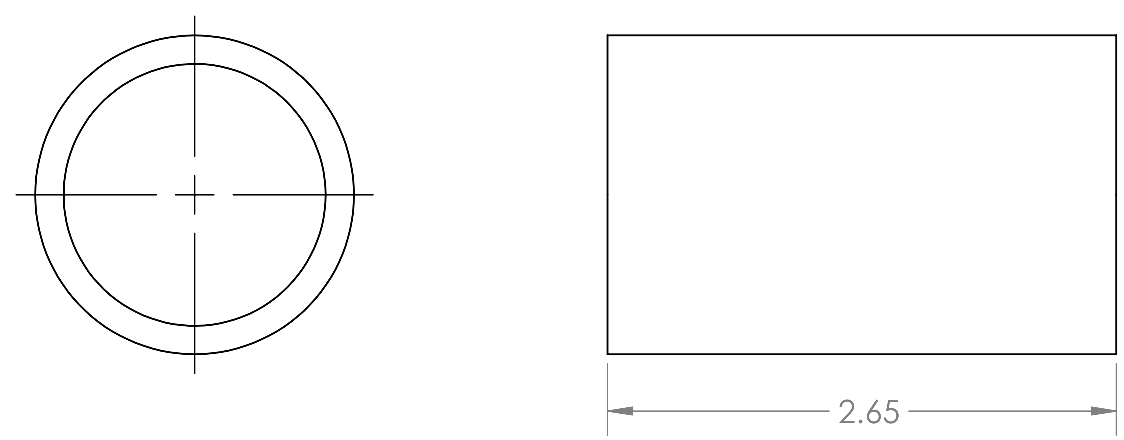
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023	TITLE: Foot Pipe (4.8")
			CHECKED			
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL 1-1/4" PVC Pipe	COMMENTS: Cut to size with PVC pipe cutter or saw. If using a pipe cutter, make sure there is at least 1" of material on either side of the blade to reduce cut slant.			SIZE B	DWG. NO. LCR-1 Technical Drawings	REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:1	WEIGHT:	SHEET 1 OF 9





NEXT ASSY	USED ON	
APPLICATION		

UNLESS OTHERWISE SPECIFIED:

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ONE PLACE DECIMAL ± 0.25
TWO PLACE DECIMAL ± 0.1
THREE PLACE DECIMAL ± 0.01

INTERPRET GEOMETRIC TOLERANCING PER:

MATERIAL
1-1/4" PVC Pipe

FINISH

DO NOT SCALE DRAWING

	NAME	DATE
DRAWN	Myles Lack-Zell	12/08/2023
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

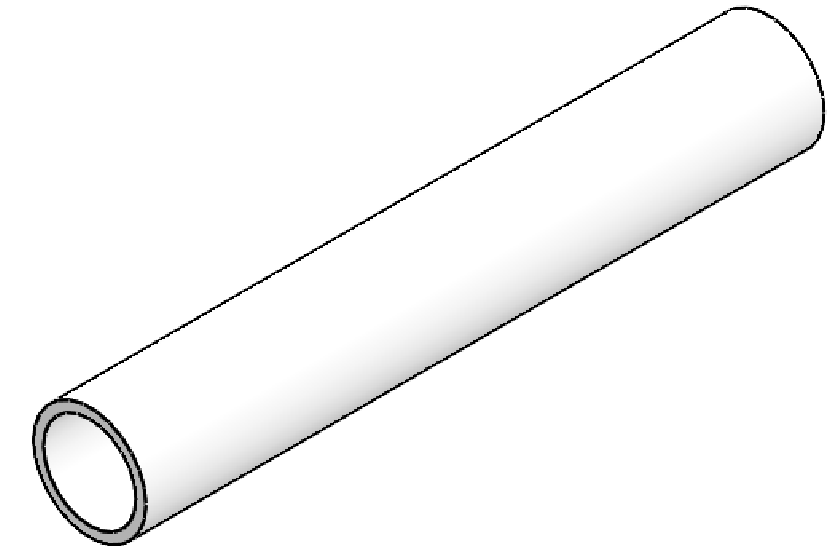
COMMENTS:
2X
Cut to size with PVC pipe cutter or saw. If using a pipe cutter, make sure there is at least 1" of material on either side of the blade to reduce cut slant.

Olin College SCOPE VIEW 2.0

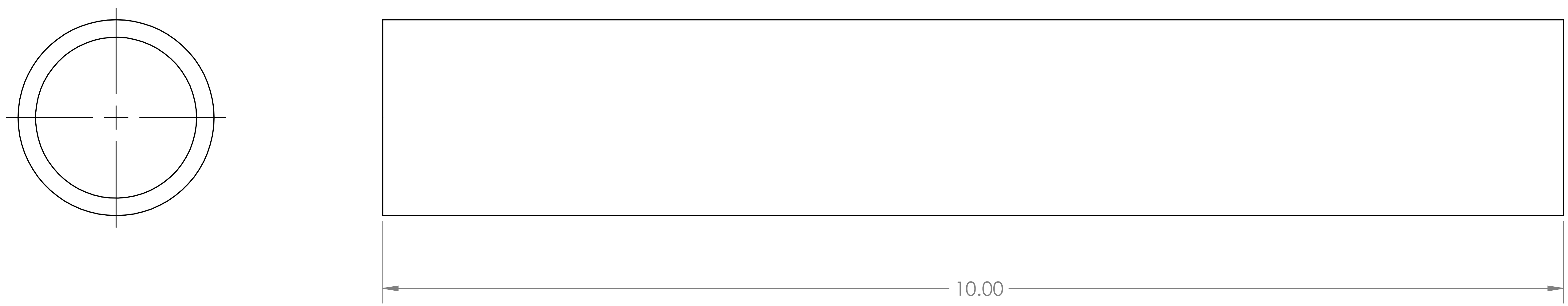
TITLE:
2X Wheel Pipe (2.65")

SIZE **B** | DWG. NO. LCR-1 Technical Drawings | REV

SCALE: 1:1 | WEIGHT: | SHEET 2 OF 9



NOTE: ISOMETIRIC VIEW
SHOWN AT 1:2 SCALE



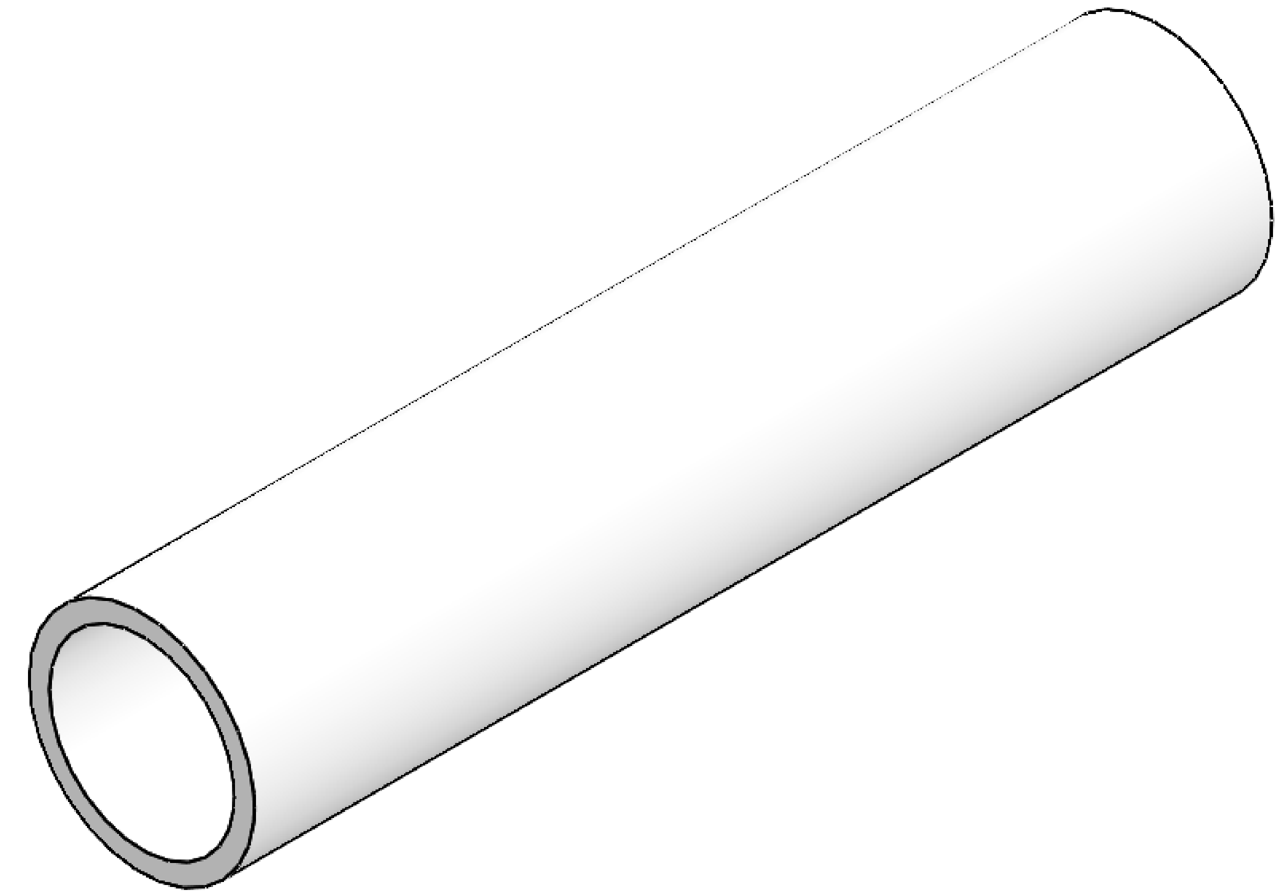
		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL 1-1/4" PVC Pipe	COMMENTS: Cut to size with PVC pipe cutter or saw. If using a pipe cutter, make sure there is at least 1" of material on either side of the blade to reduce cut slant.		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

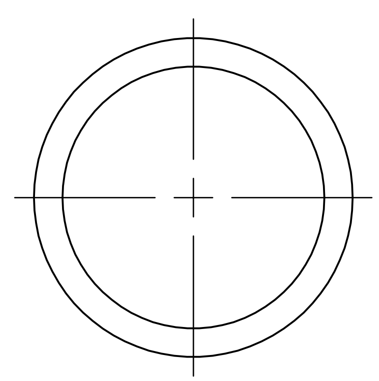
Olin College SCOPE VIEW 2.0

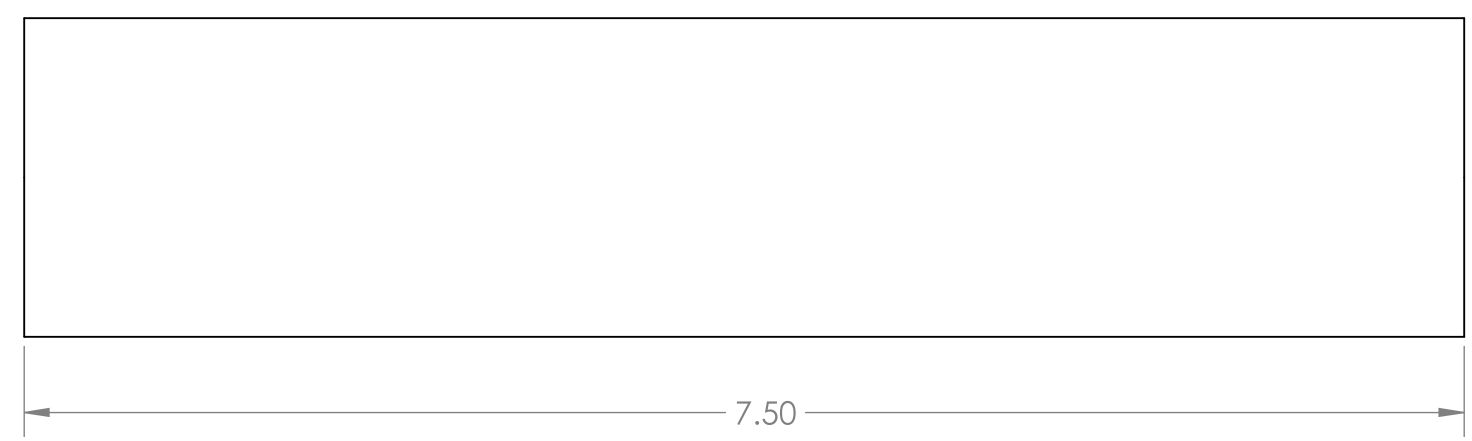
TITLE:

Torso Pipe (10")

SIZE	DWG. NO.	REV
B	LCR-1 Technical Drawings	
SCALE: 1:1	WEIGHT:	SHEET 3 OF 9







UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL 1-1/4" PVC Pipe	COMMENTS: Cut to size with PVC pipe cutter or saw. If using a pipe cutter, make sure there is at least 1" of material on either side of the blade to reduce cut slant.		
FINISH			
DO NOT SCALE DRAWING			

NEXT ASSY	USED ON
APPLICATION	

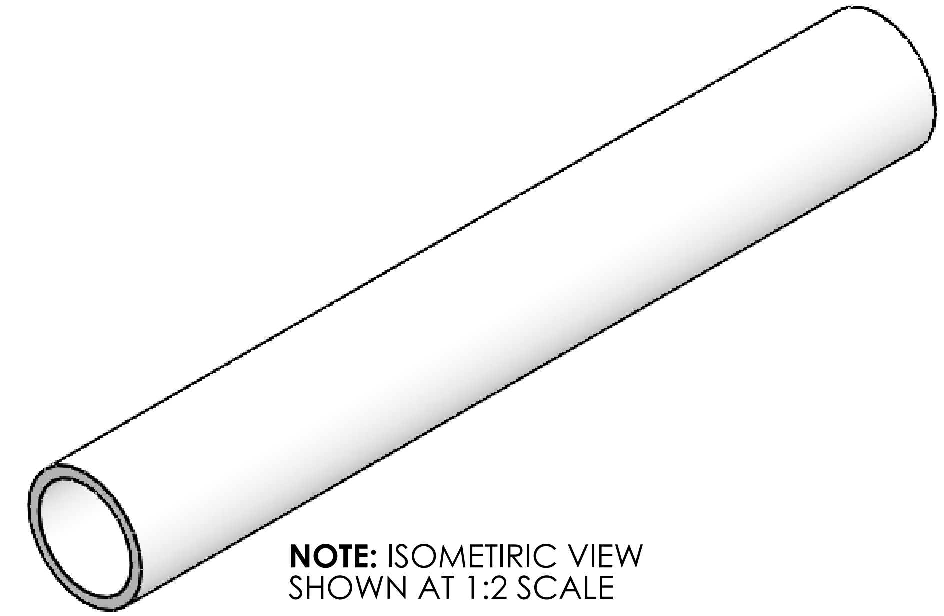
Olin College SCOPE VIEW 2.0

TITLE:

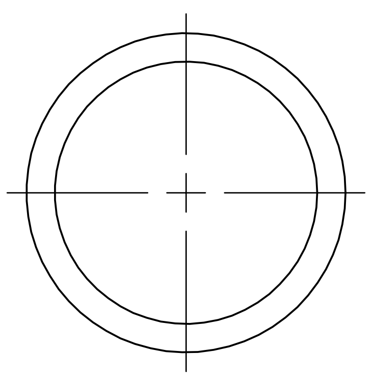
5th F Pipe (7.5")

SIZE **B** | DWG. NO. LCR-1 Technical Drawings | REV

SCALE: 1:1 | WEIGHT: | SHEET 4 OF 9



NOTE: ISOMETIRIC VIEW
SHOWN AT 1:2 SCALE



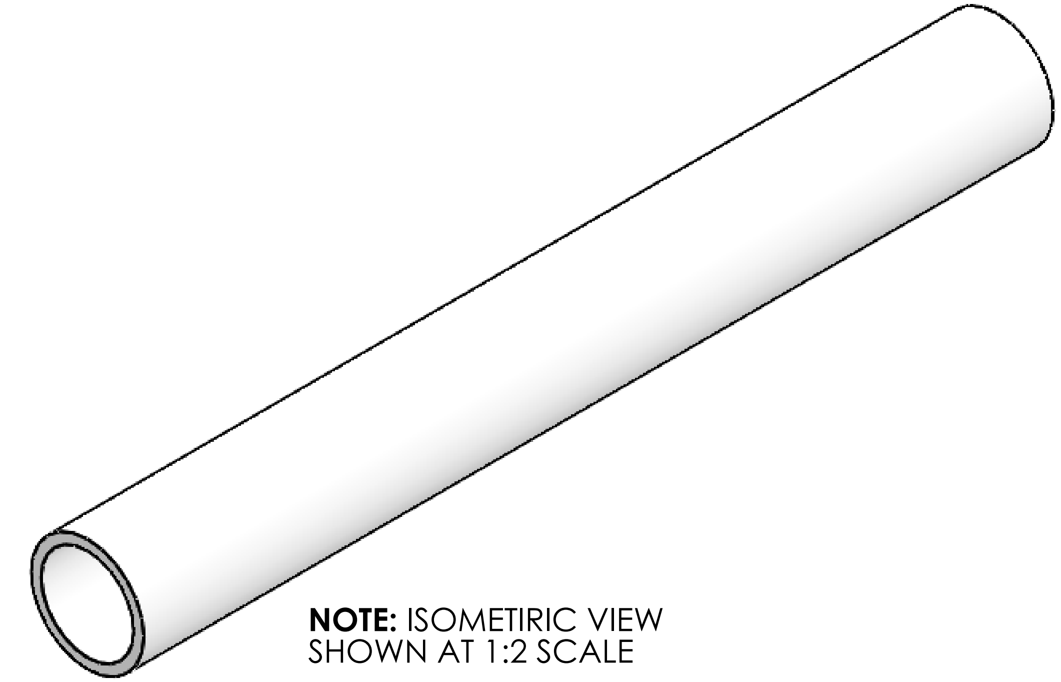
UNLESS OTHERWISE SPECIFIED:		NAME / DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell / 12/08/2023
	CHECKED	
	ENG APPR.	
	MFG APPR.	
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.	
MATERIAL 1-1/4" PVC Pipe	COMMENTS: Cut to size with PVC pipe cutter or saw. If using a pipe cutter, make sure there is at least 1" of material on either side of the blade to reduce cut slant.	
FINISH		
NEXT ASSY / USED ON		
APPLICATION	DO NOT SCALE DRAWING	

Olin College SCOPE VIEW 2.0

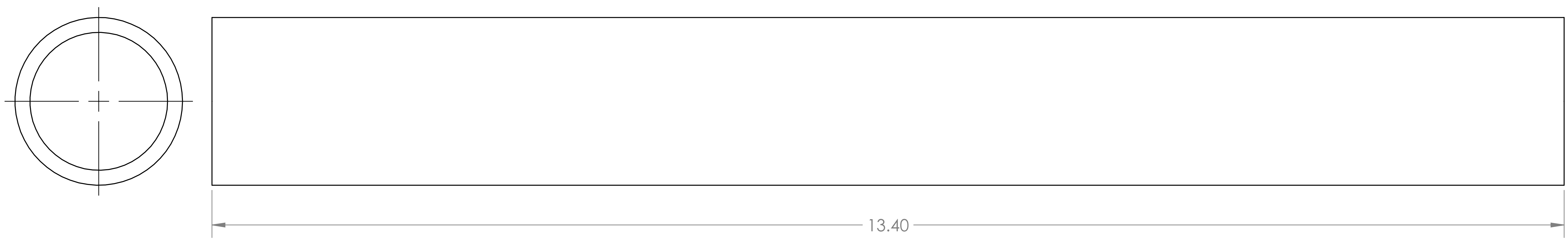
TITLE:
50th M Pipe (11.7")

SIZE **B** | DWG. NO. LCR-1 Technical Drawings | REV

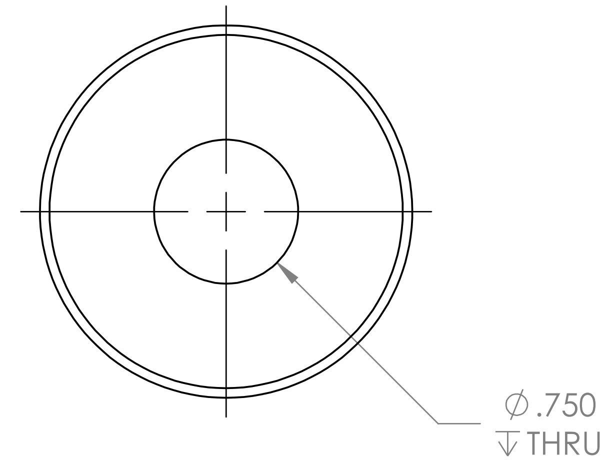
SCALE: 1:1 | WEIGHT: | SHEET 5 OF 9

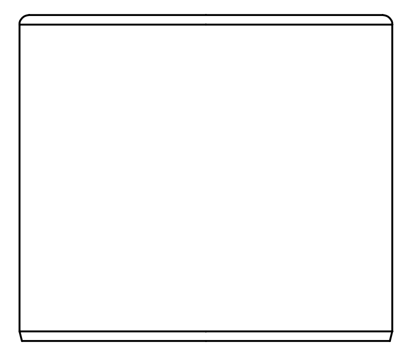


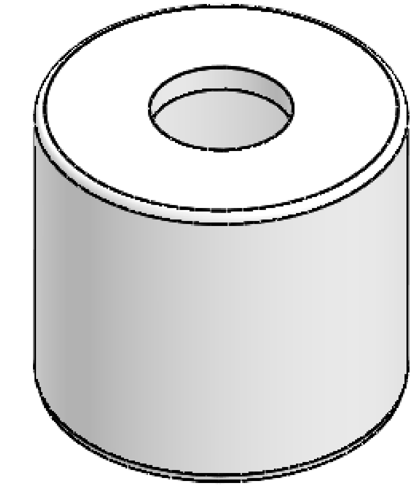
NOTE: ISOMETIRIC VIEW
SHOWN AT 1:2 SCALE



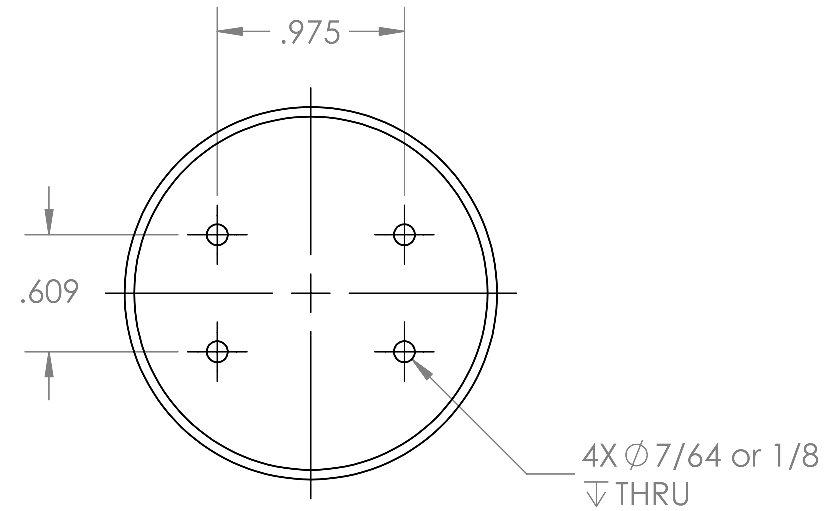
		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Olin College SCOPE VIEW 2.0
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023	TITLE: 95th M Pipe (13.4")
			CHECKED			
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL 1-1/4" PVC Pipe	COMMENTS: Cut to size with PVC pipe cutter or saw. If using a pipe cutter, make sure there is at least 1" of material on either side of the blade to reduce cut slant.			SIZE B · DWG. NO. LCR-1 Technical Drawings · REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:1 · WEIGHT: · SHEET 6 OF 9

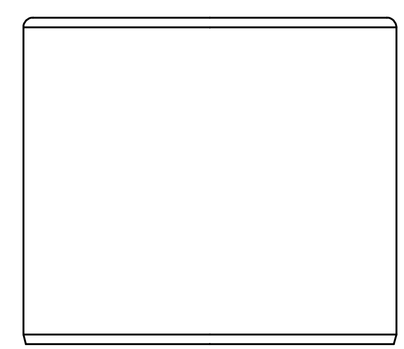


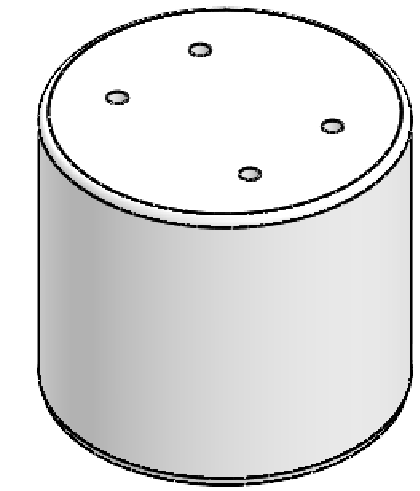




		UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Olin College SCOPE VIEW 2.0
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023	TITLE: 2X Wheel Support Cap
			CHECKED			
			ENG APPR.			
			MFG APPR.			
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.			
		MATERIAL 1-1/4" Flat PVC Endcap	COMMENTS: **2X** Mark center, clamp in place, and drill out with 3/4" forstner bit. Using a forstner bit allows the hole to be drilled in one step with a handheld drill.			SIZE **B**	DWG. NO. LCR-1 Technical Drawings	REV
NEXT ASSY	USED ON	FINISH				
APPLICATION		DO NOT SCALE DRAWING				SCALE: 1:1	WEIGHT:	SHEET 7 OF 9







UNLESS OTHERWISE SPECIFIED:		NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023
	CHECKED		
	ENG APPR.		
	MFG APPR.		
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
MATERIAL 1-1/4" Flat PVC Endcap	COMMENTS:		
FINISH			
DO NOT SCALE DRAWING			

NEXT ASSY	USED ON
APPLICATION	

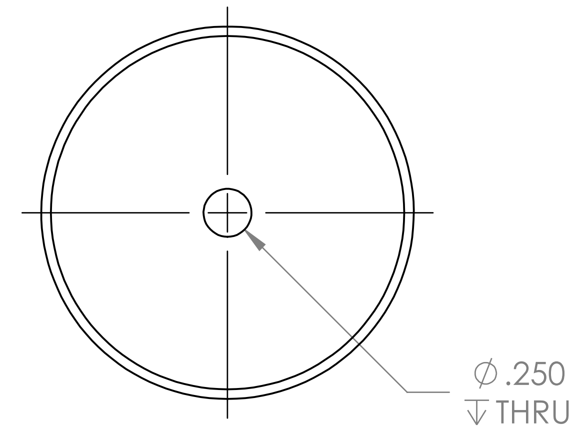
Olin College SCOPE VIEW 2.0

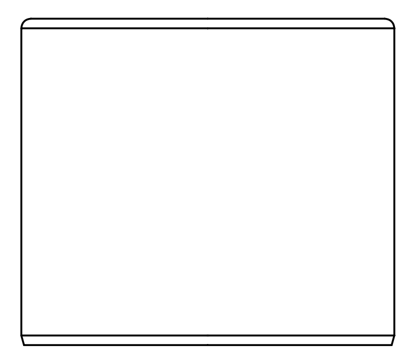
TITLE:

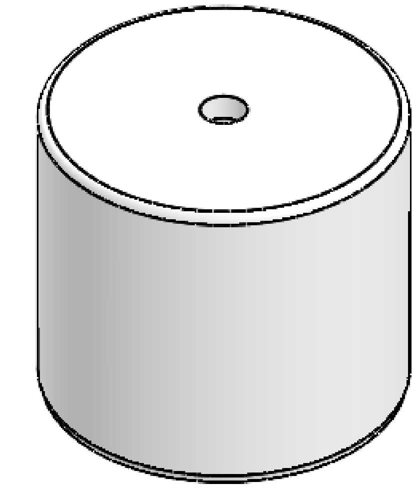
Foot Mount Cap

SIZE B | DWG. NO. LCR-1 Technical Drawings | REV

SCALE: 1:1 | WEIGHT: | SHEET 8 OF 9







UNLESS OTHERWISE SPECIFIED:		NAME	DATE	Olin College SCOPE VIEW 2.0	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ONE PLACE DECIMAL ± 0.25 TWO PLACE DECIMAL ± 0.1 THREE PLACE DECIMAL ± 0.01	DRAWN	Myles Lack-Zell	12/08/2023	TITLE:	
	CHECKED			Top Mount Cap	
	ENG APPR.				
	MFG APPR.				
INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.				
MATERIAL 1-1/4" Flat PVC Endcap	COMMENTS: Mark center, clamp in place, and drill out with 1/4" drill bit. Starting with a center punch or pilot hole may help with alignment on handheld drills.			SIZE B	DWG. NO. LCR-1 Technical Drawings	REV
FINISH					
DO NOT SCALE DRAWING				SCALE: 1:1	WEIGHT:	SHEET 9 OF 9

NEXT ASSY	USED ON
APPLICATION	

Appendix K – User Testing Plan

VIEW 2.0

User Experience Test Document

Version 1

Claire Hashizume

April 29th, 2024

Template adopted from usability.com Usability Test Plan

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Document Overview

This document describes a test plan for conducting UX testing during the reimagining of VIEW in the 2023-2024 academic year. The goals of these tests include identifying pain points and potential design concerns, evaluating how desirable this experience is, and understanding where users get lost or confused. These goals will support any redesign or iteration of the VIEW experience to improve the efficiency, end-user satisfaction, and experience of VIEW 2.0.

Executive Summary

VIEW was first created in 2017-2018 by the Olin College Senior Capstone Program in Engineering (SCOPE) team partnering with the Volpe National Transportation Systems Center and funded by the Santos Family Foundation. VIEW presents a multitude of opportunities to improve the experience of users interacting with the VIEW ecosystem. We created a UX strategy by aligning on possible use cases of VIEW 2.0 to design specific experiences for the various needs of users:

Category 1 (power users): People who prioritize precise data from high-volume measurement, even if the system has a higher barrier of entry. Ex. Volpe, IIHS
Category 2 (fleet managers): People who want an accessible tool for low-volume measurement, such as for taking measurements of an existing fleet of vehicles. Ex. City of Boston, NTSB

Category 3 (advocates): People who access the dataset generated by VIEW but do not take measurements themselves. Ex. safety advocacy groups, reporters

Through our research, we aim to understand two main areas for improvement. First, we want to evaluate the current VIEW ecosystem created by the previous SCOPE team. This ecosystem consists of the VIEW site and the measurement process to collect the data needed for the site to calculate blind zone information. Insights gathered in this phase will support our redesign decisions to make data-driven designs. Next, we want to evaluate our redesigned experience before the completion of our project. Through both phases, we conducted evaluative research to assess and improve the VIEW ecosystem by gathering user data and insights to see how it meets user needs, how easy it is to use, and how positive user satisfaction is. Both formative and summative research methods were used to identify specific usability issues and to evaluate the overall performance and impact of VIEW.

Recruitment Plan

We will recruit participants or proxies interested in vehicle safety and represent our target user demographic of people over 21 who own or use vehicles. Other user groups we would like to have represented are researchers and vehicle safety industry professionals, government transportation offices, advocacy groups, consumer reports, and more. To test the website user experience, we will recruit proxies and participants for both general and specialized backgrounds to represent our target demographic. For the measurement process testing, we plan to recruit both vehicle safety researchers or industry professionals and everyday users.

Fall recruitment plan

We will recruit 4 students who own and drive vehicles from Olin College of Engineering to assess the website UX. The participants represent a general, nonspecialized background for our Category 2 users of VIEW. We will also talk to 3-4 researchers/industry professionals from Volpe and IIHS to understand both the website UX and measurement process testing.

Spring recruitment plan

We plan to use a combination of Lyssna's panelists and our own contacts to source US participants. For the website UX testing, we aim to recruit 8 participants from Lyssna's participant panelists. These panelists should represent a general, nonspecialized background and will not have experience or familiarity with the VIEW platform. We will also recruit 1-2 participants from City of Boston, MassDot, or Together for Safer Roads. For the measurement process testing, we will use our own user database. We aim to recruit 4-5 participants who will represent both a nonspecialized and specialized background.

Testing Plan and Timeline

Phase 1 (Fall 2023):

Research Goals:

- Understand pain points and usability issues with VIEW site and measurement experience.
- Discover areas of improvement for site navigation, content, visualizations, and impression of the site.
- Learn what is working well in the current VIEW site.
- Learn magic wand answers and changes users would like to make to the current process.

Research Questions:

- How does the site architecture meet, or fail to meet, user expectations?
- How easy is it for users to understand the blind-zone visualizations?
- What parts of the site can be improved? What can be kept the same?

Methodology:

Method(s)	Qualitative usability testing In-depth user interviews
Study design	Moderated
Participants	3-4 Category 2 users (Website UX testing) 2-3 Category 1 users (In-depth Experience interviews)
Incentives	Snacks and beverages
Length	30-minute sessions
Stimuli	Current VIEW Webapp on desktop

Timeline:

Date	Action Items
10/18-11/3	Recruit participants for testing and interviews
10/27-11/8	In-depth user interviews with power users
11/8-11/10	Conduct usability testing
11/11-11/15	Synthesize UX testing results

11/15	Present insights to Liaisons

Key learnings:

- Homepage didn't really convey site purpose and next steps
- Site seems outdated and visuals can be improved
- Information about direct vision is useful and should be in a more prominent place
- Blind-zone visualization can be clearer
- Remove 1 ft scale in legend for visualizations
- Process to mark photos is frustrating
- Confusing to use the site
- Analysis is unreliable and slow

Phase 2 (Spring 2023):

Research Goals:

- Test and receive feedback on the redesigned VIEW website and measurement experience
- Validate hypotheses that pain points uncovered in Phase 1 have been addressed.
- Identify areas where the user navigation can be improved.
- Evaluate what information is helpful to include to optimize blind zone visualizations.

Research Questions:

- What information is confusing for users to understand?
- What is the user's overall satisfaction with the website and measurement process?
- What improvements can be made to increase user satisfaction?

Methodology:

Method(s)	Qualitative usability testing In-depth user interviews
Study design	Unmoderated (Website UX testing) Moderated (Website UX testing) Moderated (Measurement process)
Participants	6-8 Category 2 users (Website UX testing) 2-3 Category 1 users (Measurement process)
Incentives	Gift Card payments, Lyssna's payment
Length	15-45 minute sessions
Stimuli	Current VIEW Webapp on desktop or Figma mockups Vehicle

Timeline:

Date	Action Items
2/7-2/14	Create UX test plan and overview.

2/14-2/28	Create Figma prototype and test on Lyssna for website experience testing
2/28-3/4	Conduct unmoderated website testing
2/21-3/6	Recruit participants for measurement experience testing.
2/28-3/1	Synthesize website UX testing results
3/29	Conduct measurement experience testing
3/28-4/10	Synthesize measurement experience testing
3/8	Redesign experience based in testing insights

Key learnings:

- The site purpose was more clearly identifiable than the previous landing page.
- Opportunity to be even more descriptive with the visualizations and why blindzone safety is so important.
-

Appendix

Phase 1 Website User Experience Script

Introduction

Hello! My name is Claire and I'm going to walk you through today's session. As I mentioned in the informed consent, I'm on Olin College U.S DOT Volpe Center / Santos Family Foundation SCOPE team at Olin College, and we are working on improving the VIEW blind-zone measurement tool to help better inform people of blind spots of vehicles. Feel free to grab a muffin and iced tea.

I want to begin by saying your feedback is valuable to us, and there are no right or wrong answers. We're looking for honest feedback, and we were not part of the team that developed this so we will not get offended.

We have a formal consent narrative written up, but wanted to ask you for your permission if we can zoom record the screen during the session. It will only be used within our team for internal purposes. When collecting information, we will use pseudonyms to keep participants' identities anonymous.

For this session, we will have you complete a series of tasks on the VIEW site and hear your thoughts.

Before we begin, do you have any additional questions?

Task description

1. Is it ok if we screen record your screen?
2. Open VIEW (https://blindzonecalculator.herokuapp.com/)
1. You should be on the home page. Spend a few minutes exploring the page. Make sure to voice your thoughts out loud.
2. What do you think the purpose of this site is? What information do you believe you can find?
3. What do you expect the 'Visualize' Tab to contain? What information would be useful, and presented in what way?
4. Please go to the 'Visualize' Tab. Is this what you expected to see?
5. Look for the 2010 HONDA CR-V that was added on September 13th. Navigate to the visualization for it.
6. Spend a few minutes viewing the visualizations and navigating the page. Please make sure to say your thoughts out loud.
7. What, if anything, is helpful?
8. What, if anything, is unhelpful?
9. Feel free to explore any of the other tabs or other parts of the site.

Wrap up

10. If you had a magic wand, how would you change the experience of using the VIEW Webapp?
11. What are your overall impressions of this process?
12. What, if anything, was helpful?
13. What, if anything, was unhelpful?
14. Are there any additional comments you would like to add?

Thank you for your time and invaluable insights. It's been truly helpful. If you have any questions or additional feedback, feel free to share. Your input is central to our work.

Phase 1 Measurement Experience Interview Questions

Preparation

- Ask users to collect any photos they have of the measurement process (the space, tools, themselves, etc.)

Questions

- If you can remember, how many times have you taken measurements and of how many vehicles?
- When was the last time they took measurements and used the VIEW app?
- What was it for?
- What tools do you use?
- Can you walk me through the process from start to finish of taking the measurements and uploading it to VIEW? How long does it take?

- How does the space look like? (if they don't explain in previous question)
- How accurate are the outputs of the measurement?
- (if they have photos) Show photos and ask them to describe each photo in detail.

Wrap-up

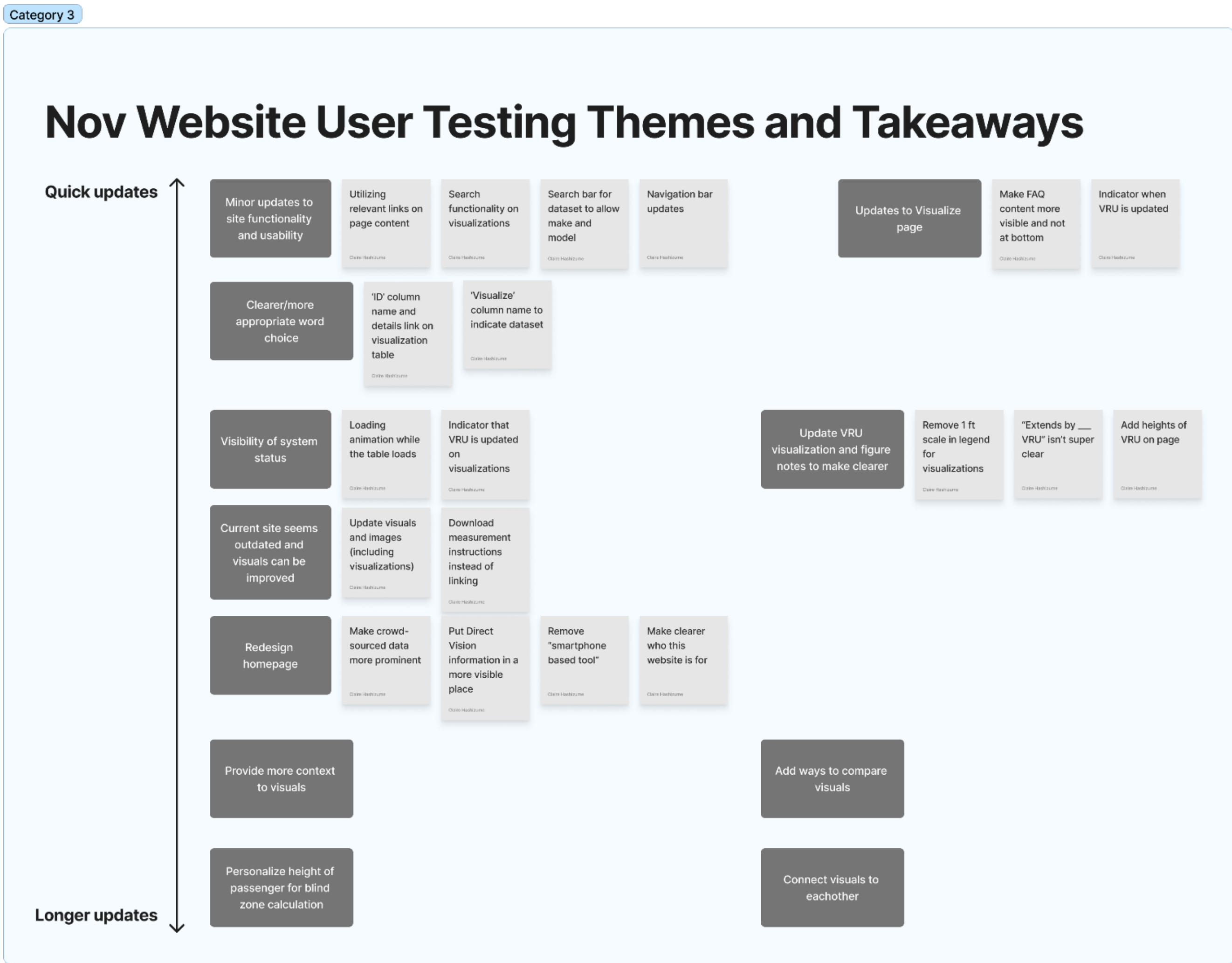
- If you had a magic wand, what would you change about the experience?
- What was the most confusing or unhelpful thing about the experience?
- What is helpful about the experience?
- Are there other people you know that have taken vehicle measurements that may be willing to be interviewed?

Phase 1 Insights

Website User Experience

- Homepage didn't really convey site purpose and next steps
    - "I first thought this was an information site for a smartphone app until I went to FAQs"
    - "My first thought when I saw the home page is a free smartphone-based tool, but where's the tool, how do I use it, I'm on a desktop website"
    - "To be honest, I don't really understand what's happening"
    - "I knew there was an app, but I didn't see the app anywhere"
- Site seems outdated and visuals can be improved
    - "Carousel seems like it was created 10 years ago with the font and everything"
    - "Overall, the site feels amateurish. It's confusing that there's an app and a table. Feels like it should be 2 separate things"
    - "I would love to make this site a lot more beautiful"
    - "This feel liks, oh, I feel like this was made in 2005 by the US government"
- Information about direct vision is useful and should be in a more prominent place
    - "I didn't know what a blind zone is, the word I've heard more is blindspot"
    - "I didn't know those (indirect vs direct vision) were two different things"
    - (In response to 'What is direct vision')
        - "This makes me care a lot more about what's happening now. I would love to know this fact before starting to deep dive into it"
        - "There you go, that I would've liked ot know beforehand"
- Blind-zone visualization can be clearer
    - "Extends out by two elementary school children" is not super clear
    - "I don't really understand this"
    - "Oh, here are the heights, I could have used that earlier"
    - "Maybe having this be like some indicator of an elementary school student like a kid with a backpack. This feels like a miniature adult right now"
- Remove 1 ft scale in legend for visualizations
    - "1ft scale in legend is confusing, is it just a symbol in the legend?"
    - "1 foot scale in passenger side blindzone isn't super helpful, I thought it was part of the car. A scale above or below the people will be significantly helpful"


Category 3
Nov Website User Testing Clustered Themes
Confusion with "smartphone based tool"
Current site seems outdated and visuals can be improved
What's working
Pretty straightforward
Minor updates to usability
Confusion for next steps from Home page
Confusion on who the website is for
Minor updates to site functionality
Visibility of system status
Some visualizations are not helpful
Remove 1 ft scale in legend for visualizations
Clearer/more appropriate word choice
Connect visuals to eachother
Provide more context to visuals
Make the information in FAQ on Visualize page more visible
Update VRU visualization and figure notes to make clearer
Direct Vision information is really useful, should be in a more visible place
Add ways to compare for visuals
Personalize height of passenger for blind zone calculation
Other homepage improvements
Make crowd-sourced data more prominent

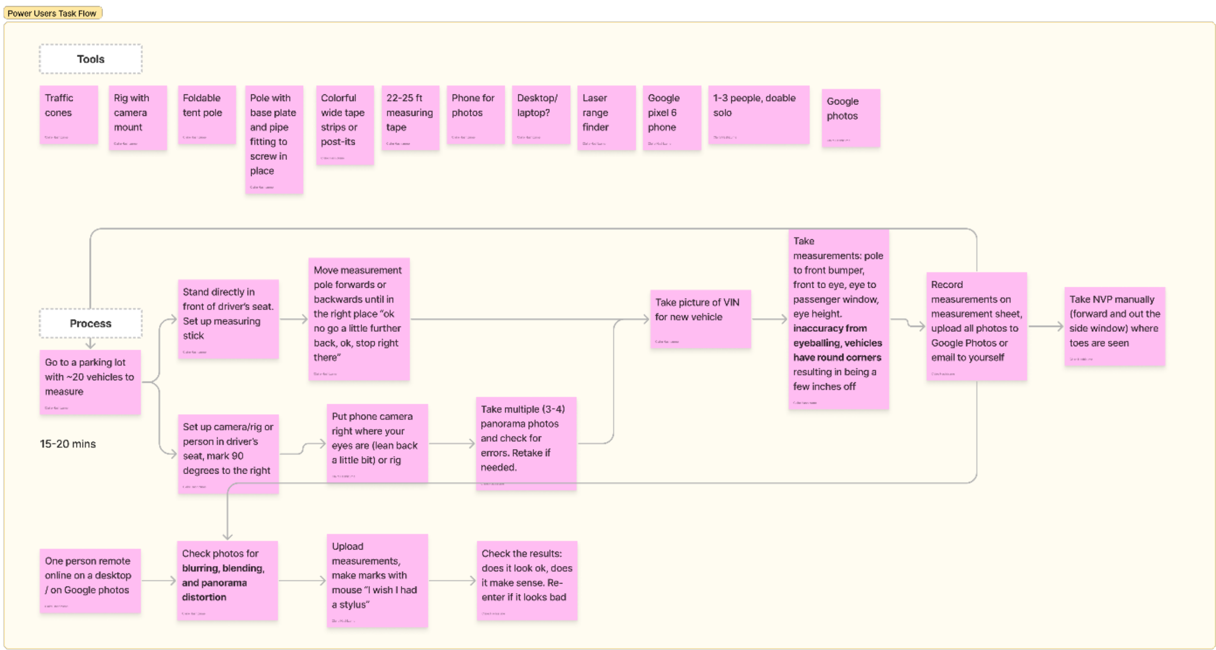


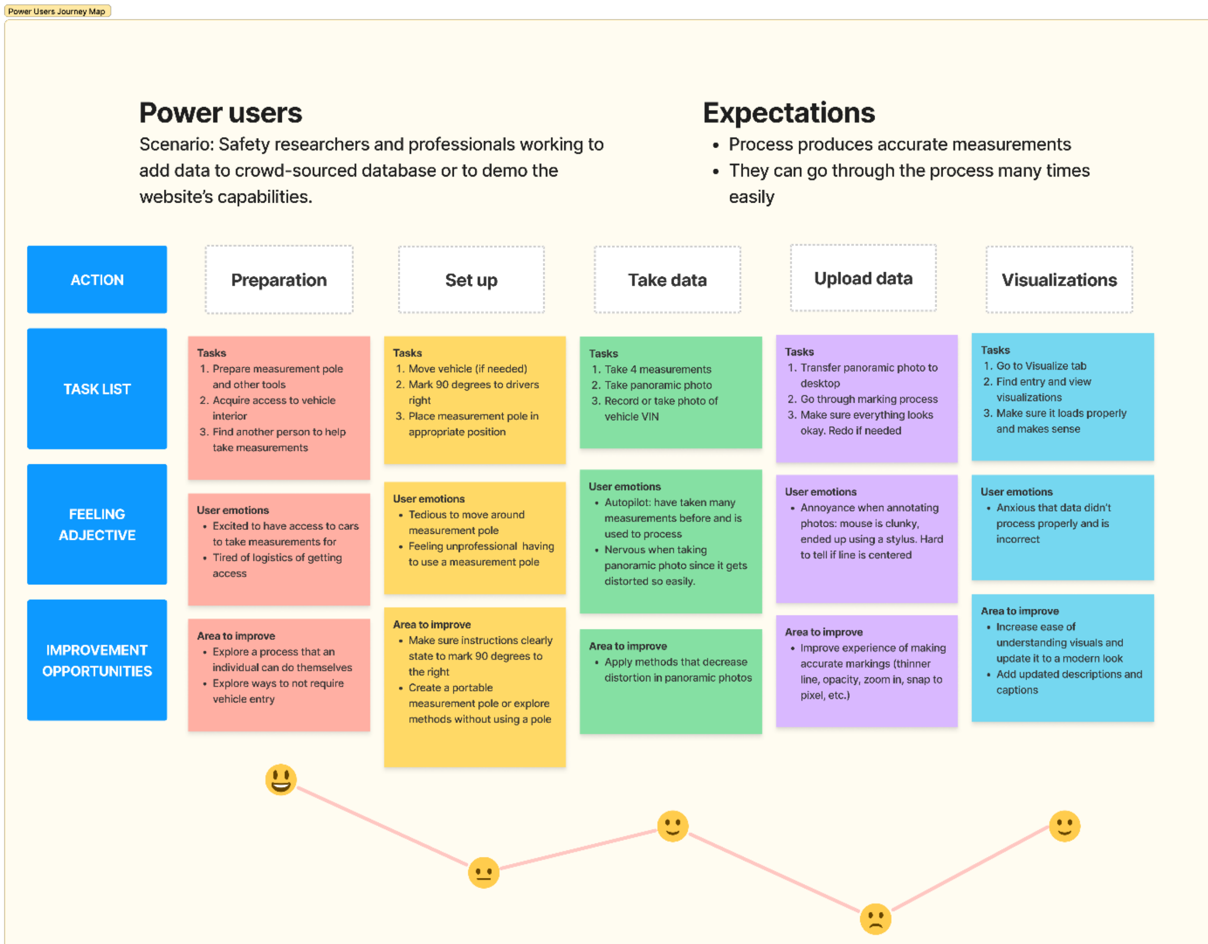
Measurement Experience

- Process to mark photos is frustrating
    - Drawing lines is subjective and takes time without a touchscreen since the mouse is clunky.
    - There is a lack of forward-backward navigation and visibility of what step users are on
    - It is difficult to understand how to mark things: where to start and stop annotation, what surface to mark
    - There is no option to erase annotations instead of clearing
- Confusing to use the site
    - "Some of these users are not engineers", and the site should support those users
    - Three researchers failed to use the site correctly the first time.
    - Wording is confusing
- Analysis is unreliable and slow
    - Different phones produced different blind-zone results

- There is lots of distortion and blurring in the panorama photo, especially the passenger side

Phase 1 Measurement Experience Journey Flows





Phase 2 Website Redesign Script and Questions

Introduction

Hello! For my Senior Capstone project, I am working on improving a blind zone measurement tool and site called VIEW.

For the test, you will view a couple screens from the website and answer some questions. I want to begin by saying your feedback is valuable to us and there are no right or wrong answers, so please share as much as possible. You may scroll up and down to view the entire page, but please do not click on anything unless instructed to.

Context

Today, you will be visiting the VIEW Blind-zone calculator site. There are several types of people who will be using this site: drivers looking to purchase a new car, advocates creating policy for safer roads, vehicle fleet managers that own several vehicles, professional researchers, and more. Please answer the questions based on what these types of people may think.

Questions

1. Take a few minutes to look at the page displayed. **[Show photo of the VIEW homepage]**

   - **a.** What is the site's purpose?
   - **b.** What actions can you take on this site?
   - c. Scroll to the top of this page. What do you expect to see if you go to *Vehicle Database?*
   - d. What do you expect to see if you go to *Add Vehicle?*
   - *e.* What, if anything, is confusing or hard to understand?
   - *f.* What additional information, if any, would you like to know from this page?
2. Say that you wanted to find the blind zone information for a Honda Odyssey. Here is the vehicle page. **[Start prototype of visualization flow]**
   - a. What is the difference between selecting the 'Preschool Child' vs 'Wheelchair user' for the visualizations?
   - b. Please go to the visualizations for a preschool child. If you get stuck, move on to the next step.
      - i. I was able to complete this step correctly.
      - ii. I'm unsure if I completed this step.
      - iii. I could not complete this step.
   - c. If you became stuck, please select the circle next to Preschool child. The “Generate Visualizations” button should now be dark blue. Please click it.

     You should now see the “Visualization Results with Preschoolers” section of the page. Go ahead and spend a couple minutes looking at the information being shown.

     When you are ready, please describe the diagrams and information being shown.
   - d. On a scale of 1 to 5 from “I understand nothing” to “I understand everything”, how would you rate your understanding of the blind zones with preschool children for the Honda Odyssey?
      - i. 1- I understand nothing
      - ii. 5- I understand everything
   - e. Why did you rate your understanding in that way?
   - f. If you wanted to view visualizations for a wheelchair user, what steps would you take?
3. Wrap up
   - a. If you had a magic wand, how would you change the pages you’ve seen?
   - b. Thinking about the users described at the beginning, how does the site support or not support what they are looking for?
     Users include drivers looking to purchase a new car, advocates creating policy for safer roads, vehicle fleet managers that own several vehicles, professional researchers, and more.
4. Thank you

Thank you for your time and invaluable insights. It's been truly helpful. If you have any questions or additional feedback, feel free to share. Your input is central to our work.

Phase 2 Website Redesign Stimuli

- [Visualizations prototype link]
- Landing page screengrab

Landing page screengrab.

Phase 2 Unmoderated Participant Profiles

	Test Duration (mins)	Age	Gender	Education	Annual household income	Employment Status	Industry	Daily hours online	Technical proficiency
1	20.5	48	F	College graduate	Over $100,000 / year	Full-time employed	Science, Technology, Engineering & Mathematics	>6	Intermediate
2	10.5	44	F	Some college	$70,001-100,000 / year	Unemployed, seeking employment	Transportation, Distribution & Logistics	>6	Intermediate
3	11.3	37	M	College graduate	Over $100,000 / year	Full-time employed	Transportation, Distribution & Logistics	>6	Advanced
4	12.1	44	M	High school graduate	$10,001-$40,000 / year	Part-time employed	Science, Technology, Engineering & Mathematics	>6	Advanced
5	4.9	36	M	College graduate	$40,001-$70,000 / year	Full-time employed	Transportation, Distribution & Logistics	4-6	Advanced
6	24.3	29	M	Post graduate degree	$40,001-$70,000 / year	Self-employed	Science, Technology, Engineering & Mathematics	>6	Advanced

Phase 2 Unmoderated Test Responses

Today, you will be visiting the VIEW Blind-zone calculator site. There are several types of people who will be using this site: drivers looking to purchase a new car, advocates creating policy for safer roads, vehicle fleet managers that own several vehicles, professional researchers, and more. Please answer the questions based on what these types of people may think. "

1. **Take a few minutes to look at the page displayed. [Show photo of the VIEW homepage] What is the site's purpose?**
    - To point out dangers of the blind-zone
    - The site's purpose seems to be to educate users on blind zones and the blind zone measurement tool.
    - This website shows the blind zone of your vehicle so you can see and understand how safe or unsafe your vehicle is.
    - Looks like a site for a tool to measure the blind zones of your vehicle for safer driving.
    - To show you how much of a blind spot a car features.
    - this site that helps drivers avoid car accidents and drive safely
2. **What actions can you take on this site?**

- Find out about the blind zone dangers on your vehicle and learn about the blind zone measurement tool called View.
- You can add a vehicle, view the database, and view frequently asked questions.
- I can add my vehicle and get a good understanding of it blind zone.
- Add your vehicle type, learn more about blind zones, view the database, and view frequently asked questions.
- You can add a vehicle so that you can check what its blind zones are.
- It's not yet clear whether I can buy some equipment that helps me or this is just a training site

3. **Scroll to the top of this page. What do you expect to see if you go to *Vehicle Database?***
   - the blind zone dangers of your particular vehicle
   - I would expect to see a database of different types of cars and their blind zones.
   - see variety of vehicles along with their blind zone data and search for the vehicle that match my interst.
   - A list of vehicle models and their blind zone info. Including how to improve visibility.
   - a master database of all the vehicles you can pick from.
   - how this system will be installed. or which cars need it more
4. **What do you expect to see if you go to *Add Vehicle?***
   - Your vehicle information
   - I would expect to see info on my vehicle's blind zones.
   - I would be able to add the vehicle that i not in the database and see its blind zone.
   - Ability to select or search for your vehicle type.
   - It would load a new page for you to add a vehicle from.
   - if I click add vehicle I will see a form to fill out. to order installation of this equipment
5. **What, if anything, is confusing or hard to understand?**
   - Nothing stands out immediately that explains what it is and does. You have to be willing to read the whole page before it is clear.
   - Not much, though I'm not sure if I would have to pay for any aspect of the service--I'm guessing not, since it is crowdsourced, but not sure...
   - Nothing.
   - The database area could be better described. Something like, "find your vehicle model" might help.
   - nothing.
   - I couldn't immediately understand what it was. Is it possible to install this yourself, or do you need to take it to a service center? Is this suitable for all cars? website design is like dmv, a little boring.
6. **What additional information, if any, would you like to know from this page?**
   - More descriptive tag lines, specific and to the point
   - Not sure
   - NA
   - More images showing technology used might help. Like a rear view camera pic on the display on dash.
   - nothing
   - how to get a. How to install this, can I do it myself, how easy this is

Say that you wanted to find the blind zone information for a Honda Odyssey. Here is the vehicle page. [Start prototype of visualization flow]

7. **What is the difference between selecting the 'Preschool Child' vs 'Wheelchair user' for the visualizations?**
    - the section of the car it shows
    - The main difference would be the preschool child height is 28 inches and the wheelchair user height is 39 inches.
    - It is the height difference.
    - 11 inches of visibility.
    - 11 inches.
    - that's right, a child is much smaller than a wheelchair

8. **Please go to the visualizations for a preschool child. If you get stuck, move on to the next step.**
    - I could not complete this step.
    - I was able to complete this step correctly.
    - I was able to complete this step correctly.
    - I was able to complete this step correctly.
    - I was able to complete this step correctly.
    - I was able to complete this step correctly.

If you became stuck, please select the circle next to Preschool child. The “Generate Visualizations” button should now be dark blue. Please click it.

You should now see the “Visualization Results with Preschoolers” section of the page. Go ahead and spend a couple minutes looking at the information being shown.

9. **When you are ready, please describe the diagrams and information being shown.**
    - This isn't working correctly for me
    - The info shows different POV's and where the blind spots are if a preschool child/children were in the area and where you would not be able to see them from the vehicle.
    - It shows the blind spot for a preshooler based on thier height.
    - This info is very clear. The visualizations of your blind spots couldn't be done any better. It's very easy to understand.
    - I believe it is showing me where on the car you would have the blind zone. anythign that is colored is what you wouldn't be able to see them from.
    - it does not work
10. **On a scale of 1 to 5 from “I understand nothing” to “I understand everything”, how would you rate your understanding of the blind zones with preschool children for the Honda Odyssey?**
    - 2
    - 4
    - 5
    - 5
    - 2
    - 1
11. **Why did you rate your understanding in that way?**
    - I either didn't understand the directions, or the page didn't load correctly

- I understand most of it, but am less sure about the first image of the overhead view--for me that image is less clear about what is/isn't a blind zone.
- Because I can clearly understand what is being shown and understanding them are quite easy.
- I think these images convey everything you need to know perfectly.
- The scan image is a bit confusing because it doesn't explain what exactly you are looking at.
- I clicked on everything and the visualization didn't work

12. **If you wanted to view visualizations for a wheelchair user, what steps would you take?**
    - Select wheelchair user, generate visualizations
    - I would click on the "wheelchair user" button at the top of the page and "generate visualizations" again
    - All I really needed to do was ot choose wheelchair user from the previous page.
    - I would click the wheelchair user radio button at the top and hit generate visualizations.
    - You would click wheelchair user instead of preschool child.
    - I would just click on the wheelchair user or the picture

Wrap up

13. **If you had a magic wand, how would you change the pages you've seen?**
    - I don't think I would
    - I think maybe just make the overhead view a bit more clear and be consistent with coloring for blind zones vs. direct/indirect vision...
    - I think it looks perfect enough and there is no need to change anything. It was quite easy to navigate and understand the information on the website.
    - I think the car model visualizations are perfect. The main page should show a demonstration of those so people clearly understand what the tool does before selecting their model.
    - I would have a better description for the image that is shown when you click a option for the blind zone.
    - the page looks good. but instead of all the names, I would just leave pictures with the names under them so that you can click on the picture and get a visualization

14. **Thinking about the users described at the beginning, how does the site support or not support what they are looking for?**

    Users include drivers looking to purchase a new car, advocates creating policy for safer roads, vehicle fleet managers that own several vehicles, professional researchers, and more.

- need more support for bigger work vehicles for vehicle fleet managers
- It supports them in being able to see what blind zones there are for their vehicles which could in turn help increase safety with education and possibly, vehicle re-designs...
- I think this website clearly supports all the necessary information and support a subscriber i looking for.
- I think it helps everyone to understand what areas they should be watching out for when driving.
- It provides good information, but I feel like it could better explain what the image is showing you when it shows it.

- It's difficult to answer this question. because most people don't think about blind spots when they buy a car

Phase 2 Moderated Interview Responses

Hello! For my Senior Capstone project, I am working on improving a blind zone measurement tool and site called VIEW.

I'll show you a couple of screens from the website and answer some questions. I want to begin by saying your feedback is valuable to us and there are no right or wrong answers, so please share as much as possible.

Would it be okay to record this call? No identifying information will be shared outside of my team, and the zoom recording will just be for personal use to go through afterwards.

Today, you will be visiting the VIEW Blind-zone calculator site. There are several types of people who will be using this site: drivers looking to purchase a new car, advocates creating policy for safer roads, vehicle fleet managers that own several vehicles, professional researchers, and more.

Introductions

1. **What is your role in vehicle safety?**
   a. Helped begin city of boston looking into direct vision for city vehicles (large trucks, school buses, firetrucks) in the public health lens at BPHC. Partnership for healthy cities (bloomburg) to work on policy change within city to increase active mobility
   b. Area that there was interest for was direct vision, she project managed that grant.
   c. Project managed grant for direct vision working with volpe, measured 30+ vehicles for the City of Boston with Alex
   d. So they can see where the vehicles fell within direct vision landscape to help create 5 star rating system, did analysis of vehicles, looked at what was out there to see if there were better or worse (comparing diff types of school buses) to see what makes a difference
   e. Passion project as a cyclist and pedestrian who uses city streets everyday.
   f. Now that she has an awareness of vehicle's lack of direct vision, she's a lot more aware as a cyclist of where or where they can't see her.
2. **How familiar are you with the VIEW tool?**
   a. Familiar with the process. Alex used the tool.
3. **Here is the landing page. Take a few minutes to look at the page displayed. [Show photo of the VIEW homepage] What is the site's purpose?**
   a. **What actions can you take on this site?**
      - Looks mostly like education, something that might need to be more in your face is the 'add vehicle' going into what that means- see your hidden dangers, i almost wonder if you want to start with what it is and why. Right now, looking at it, do i go to add vehicle to put my own in, what does that mean, if the goal of the site is to collect data, it might be important to put that a little more in your face. Like starting with the visuals of the blindzone and really showing people that, for this car, did you know you can't see a child? "something that makes me care in a way". Especially if

I'm just your average person who has a car and/or wants a car. Or, if you're designing it for people who have more of an understanding of what the goals are, then it makes sense.

- I might put more of the stark graphics in your face to be like "this is why you would want to measure your vehicle"
- I think I'd want to click add vehicle to see what that means. I know that the vehicle database would probably pull up the vehicles that are already measured, because I've already been on that a lot. I think it's good to have on the top there. I think I'd be able to add my own vehicle, but other than that, it would just be for me to learn a little bit more.
- I saw the three categories of vehicles, fleet, organization, I would assume I would click one of those based on who I am and why I'm on this site.
- As someone who works closely with direct vision, I'd want to be able to look up a vehicle in the database or see if it's there and maybe use that to make a case of ADAs or whatever it is. Or using it an advocacy like public health advocacy, showing the reasons why we might consider vehicles with more direct vision.

4. **Scroll to the top of this page. What do you expect to see if you go to *Vehicle Database?***

a. **What do you expect to see if you go to *Add Vehicle?***
   - 'Add Vehicle button' - what are your expectations for the next page? "Well, I would kind of wonder since I know this is an app, so if I'm on my phone, I would expect it to pull up directions on how to use the app and lead me to start using the app. If on desktop, I would wonder is this for me if I've already measured a vehicle, is this where I go into cause I already have the measurements? Or is it going to show me how to download the app and what to do from there.

b. **What, if anything, is confusing or hard to understand?**
   - I do see that the crashed car is there, how did that happen? I would say just for add vehicle, what does that even mean? I wouldn't know just from looking at it here.
   - Use cases: maybe difference between fleet manager and organization, which one do I choose if I'm a fleet manager that's part of an organization? What is access blindzone information and raise awareness, is that going to lead me to a database? A bit clearer on why I should choose fleet manager over organization?

c. What additional information, if any, would you like to know from this page?

5. Say that you wanted to find the blind zone information for a Honda Odyssey. Here is the vehicle page. [Start prototype of visualization flow]

a. "So this i would choose which of these people to visualize the car above with the blindzone? Oh that's neat"
b. "no i think this is great"
c. "I almost wonder if you want to move the blindzone visualizations to the top. When we were first here, I was like 'is this a ghost car? What is this? I see that it's a picture of the car'"
d. "Maybe to demonstrate what do i do with this car? Or even a sample at the top of a visualization to say what the goal is. If you had an example of 'here's a preschool with a honda odyssey' like select one to change or select your car or VRU to visualize whatever you want"

e. What is the difference between selecting the 'Preschool Child' vs 'Wheelchair user' for the visualizations?
f. Please go to the visualizations for a preschool child. If you get stuck, move on to the next step.

If you became stuck, please select the circle next to Preschool child. The “Generate Visualizations” button should now be dark blue. Please click it.

You should now see the “Visualization Results with Preschoolers” section of the page. Go ahead and spend a couple minutes looking at the information being shown.

6. **When you are ready, please describe the diagrams and information being shown.**
7. **On a scale of 1 to 5 from “I understand nothing” to “I understand everything”, how would you rate your understanding of the blind zones with preschool children for the Honda Odyssey?**
    a. 3.5- one thing that I always struggle with this is i see the dots are preschoolers that are hidden. And i see the blindzone is grey. So why aren’t the children filling out that whole grey space. Is it because I can see part of the child? That’s what I always wonder with these graphics. Is the grey zone just the ground they cannot see?
    b. Saying “From the ground up” or something similar
8. **Why did you rate your understanding in that way?**
9. **If you wanted to view visualizations for a wheelchair user, what steps would you take?**

Wrap up

10. **If you had a magic wand, how would you change the pages you’ve seen?**
    a. I almost want the selections to be side by side. Having the of VRU with image on one side and visual on the other. I don’t know if there’s space for that, but that way you can toggle between those two and see it change by toggling between the two. I feel like there’s kind of a lot of blank space to the left, so you can put it next to the options above.
    b. Would be interesting to make multichoice squares instead of circles so you can have wheelchair user and an adult and see like, wow, you can see an adult in all these places and you can’t see a wheelchair user in any of them. Maybe there’s a color that overlaps them. I think it would be fun to be able to see them together in a way. You can make a big statement with that
11. **Thinking about the users described at the beginning, how does the site support or not support what they are looking for?**

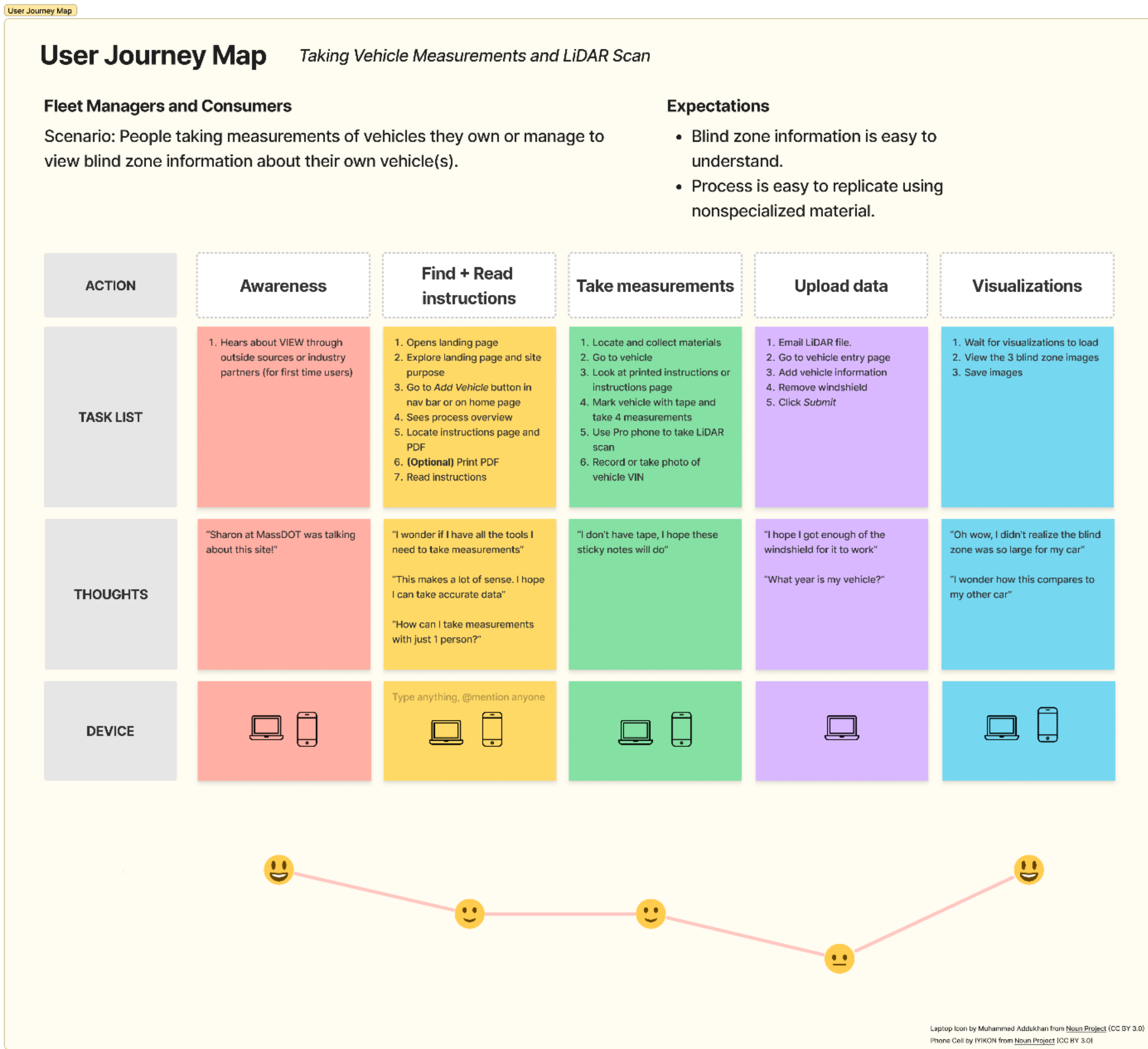
    Users include drivers looking to purchase a new car, advocates creating policy for safer roads, vehicle fleet managers that own several vehicles, professional researchers, and more.

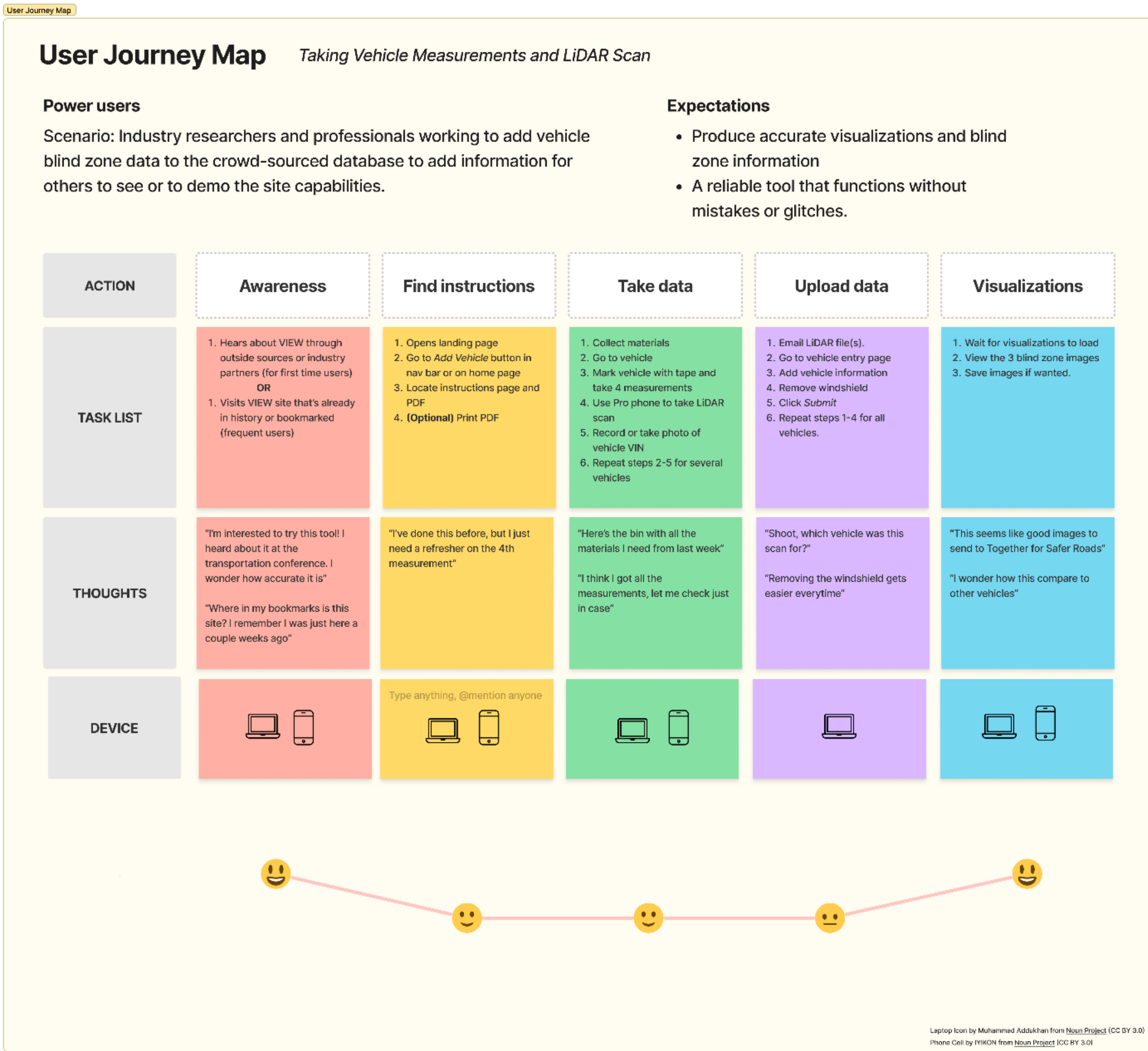
a. I think for your average person who doesn’t understand what the blindzone is and why it’s important- that's why i recommended putting what it is and an example of the view at the top to throw it in your face at first. I might just be like, this is just for someone who is interested in this. But making someone interested. I also understand Volpe doesn’t want to be biased- they're promoting safety, so throw that safety piece in your face. This is why people should care.

b. If you were to hover your mouse over vehicle database, I'd almost want something to tell me what it is. For example, a library of vehicles that have been measured, but that just might be a bit more descriptive as someone coming in who has no idea what this is.
c. Even if you have that for add vehicle, maybe that's where you have info about where it takes you.
d. I think, you mentioned coming to the site as an advocate, maybe there should be something for VRUS for 'where am I in the blindzone?' when I pass this big truck, how do i know they can see me or not. Where am I blind. You can kind of figure that out as a cyclist, but maybe one of the use cases is for VRUs and having a frame like that. You don't want to victim blame of couse, but it's educational.

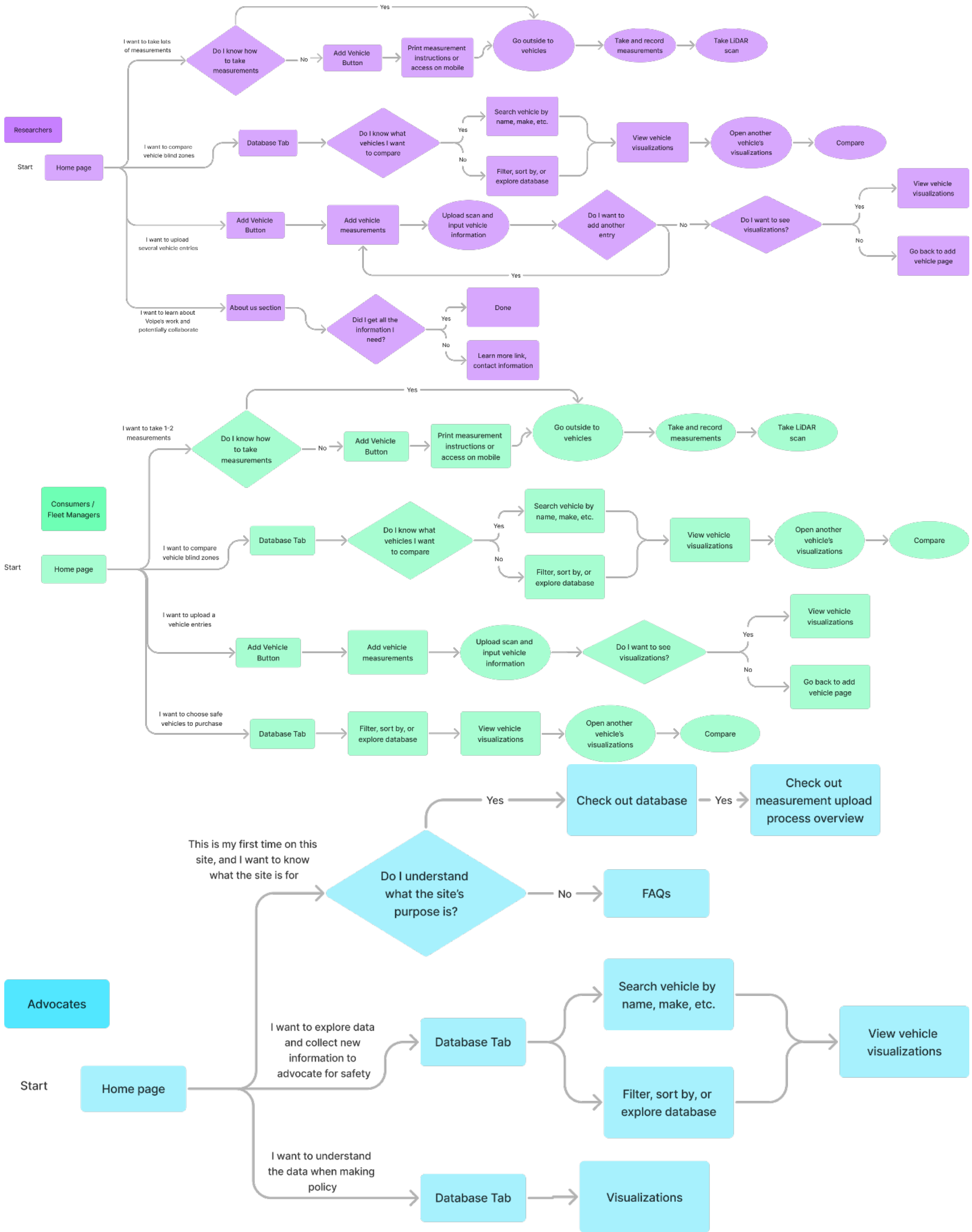
12. Do you have any questions remaining for me?

Phase 2 Journey Maps

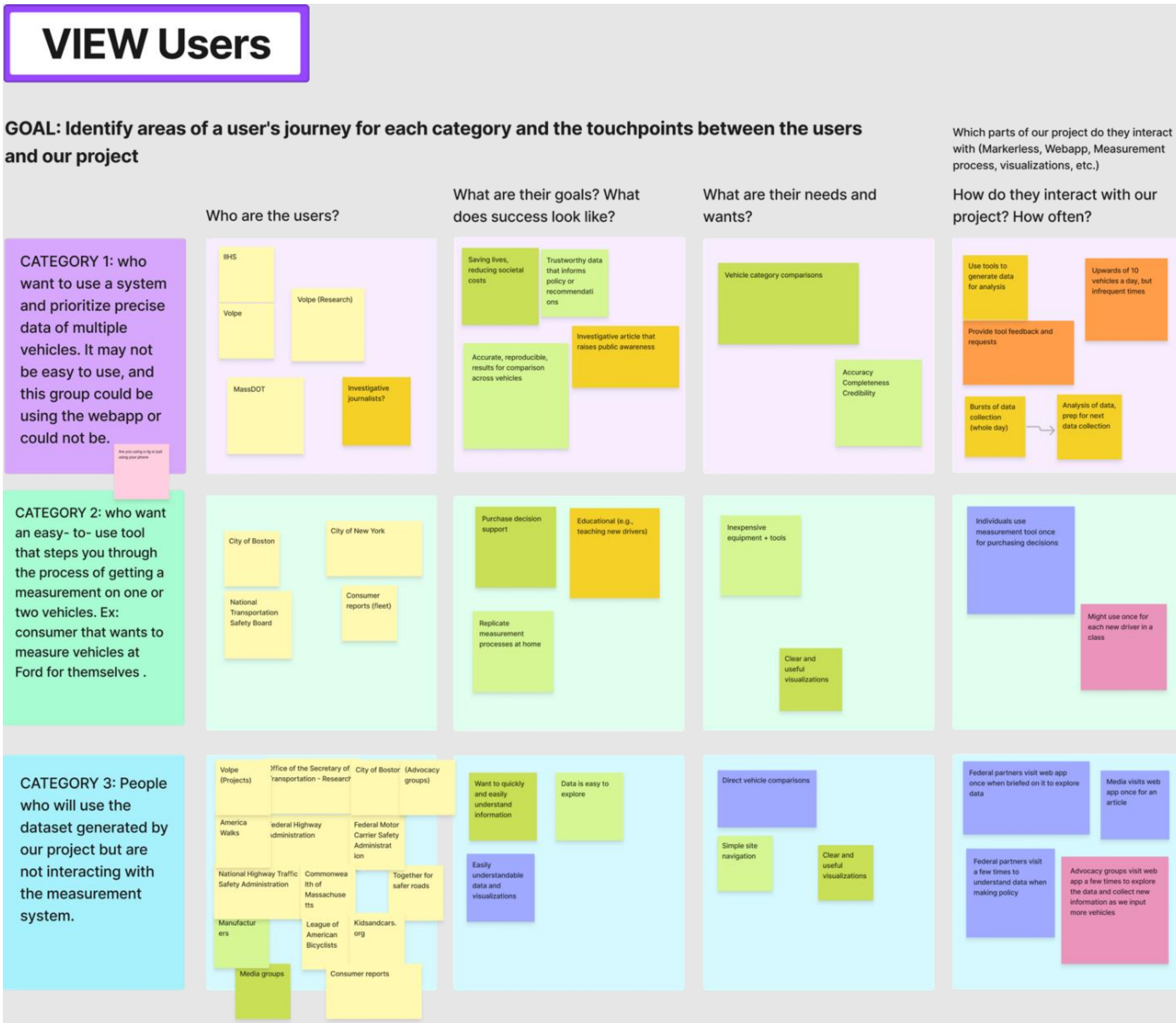

User Journey Map
User Journey Map
Taking Vehicle Measurements and LiDAR Scan
Fleet Managers and Consumers
Scenario: People taking measurements of vehicles they own or manage to view blind zone information about their own vehicle(s).
Expectations
• Blind zone information is easy to understand.
• Process is easy to replicate using nonspecialized material.
ACTION
Awareness
Find + Read instructions
Take measurements
Upload data
Visualizations
TASK LIST
1. Hears about VIEW through outside sources or industry partners (for first time users)
1. Opens landing page 2. Explore landing page and site purpose 3. Go to Add Vehicle button in nav bar or on home page 4. Sees process overview 5. Locate instructions page and PDF 6. (Optional) Print PDF 7. Read instructions
1. Locate and collect materials 2. Go to vehicle 3. Look at printed instructions or instructions page 4. Mark vehicle with tape and take 4 measurements 5. Use Pro phone to take LiDAR scan 6. Record or take photo of vehicle VIN
1. Email LiDAR file. 2. Go to vehicle entry page 3. Add vehicle information 4. Remove windshield 5. Click Submit
1. Wait for visualizations to load 2. View the 3 blind zone images 3. Save images
THOUGHTS
"Sharon at MassDOT was talking about this site!"
"I wonder if I have all the tools I need to take measurements"
"This makes a lot of sense. I hope I can take accurate data"
"How can I take measurements with just 1 person?"
"I don't have tape, I hope these sticky notes will do"
"I hope I got enough of the windshield for it to work"
"What year is my vehicle?"
"Oh wow, I didn't realize the blind zone was so large for my car"
"I wonder how this compares to my other car"
DEVICE
Type anything, @mention anyone
Laptop Icon by Muhammad Addukhan from Noun Project (CC BY 3.0)
Phone Cell by IYIKON from Noun Project (CC BY 3.0)


User Journey Map
User Journey Map
Taking Vehicle Measurements and LiDAR Scan
Power users
Scenario: Industry researchers and professionals working to add vehicle blind zone data to the crowd-sourced database to add information for others to see or to demo the site capabilities.
Expectations
• Produce accurate visualizations and blind zone information
• A reliable tool that functions without mistakes or glitches.
ACTION
Awareness
Find instructions
Take data
Upload data
Visualizations
TASK LIST
1. Hears about VIEW through outside sources or industry partners (for first time users) OR 1. Visits VIEW site that's already in history or bookmarked (frequent users)
1. Opens landing page 2. Go to Add Vehicle button in nav bar or on home page 3. Locate instructions page and PDF 4. (Optional) Print PDF
1. Collect materials 2. Go to vehicle 3. Mark vehicle with tape and take 4 measurements 4. Use Pro phone to take LiDAR scan 5. Record or take photo of vehicle VIN 6. Repeat steps 2-5 for several vehicles
1. Email LiDAR file(s). 2. Go to vehicle entry page 3. Add vehicle information 4. Remove windshield 5. Click Submit 6. Repeat steps 1-4 for all vehicles.
1. Wait for visualizations to load 2. View the 3 blind zone images 3. Save images if wanted.
THOUGHTS
"I'm interested to try this tool! I heard about it at the transportation conference. I wonder how accurate it is"
"Where in my bookmarks is this site? I remember I was just here a couple weeks ago"
"I've done this before, but I just need a refresher on the 4th measurement"
"Here's the bin with all the materials I need from last week"
"I think I got all the measurements, let me check just in case"
"Shoot, which vehicle was this scan for?"
"Removing the windshield gets easier everytime"
"This seems like good images to send to Together for Safer Roads"
"I wonder how this compare to other vehicles"
DEVICE
Type anything, @mention anyone
Laptop Icon by Muhammed Addukhan from Noun Project (CC BY 3.0)
Phone Cell by IYIKON from Noun Project (CC BY 3.0)

Redesigned User Task Flow



Appendix L – VIEW Ecosystem user goals, needs, interactions



VISION

What is the improved future state of where the user experience is going and why?

Category 1	Create a process for researchers and industry professionals to collect accurate, complete and credible data using specialized tools to enable them create comparisons across vehicles in order to inform policy and make recommendations.
Category 2	Improve the experience to allow non-researchers interested in taking measurements for blind spot calculation to replicate the measurement process easily without taking too long in order to support purchase decisions or to educate new drivers.
Category 3	Deliver a platform that allows anyone interested in vehicular blind spots to explore a site with simple navigation to quickly and easily understand data visualizations.

GOALS

How we'll know if we're making progress

Category 1	Increase accuracy of blind-zone data results and professionalism in methodology used to obtain collect data.
Category 2	Address pain points in the current experience and create a new method that requires less time and materials to take measurements. Increase success in navigating the VIEW site and understanding of data visualizations.
Category 3	Increase success in navigating the VIEW site and increase understanding the various data visualizations.

PLAN

The path we take to get there

Category 1	Set up markerless with IIHS, Volpe, and Olin. Decide if Markerless will be used in the VIEW webapp in the backend. If not, test and redesign the Markerless interface to create a better experience for power users. Test the accuracy and validity of the system.
Category 2	User test and in-depth interviews with users about the current experience while researching improvements in methodology. Make design revisions based on our findings. Explore methodologies that simplify data collection and upload.
Category 3	Test the visuals and database with Olin students. Find areas of opportunity and pain points, redesign the webapp and visuals, iterate, and test again to check for improvements.

Appendix M – VIEW 1.0 Site Audit

Home Add Vehicle Visualize FAQ

Our Free, Smartphone-Based Blind Zone Measurement Tool Enables:

Compare and select the best-in-class direct vision makes and models

Understand the risks of blind zones

Discover how much can be seen from their vehicle and risk to Vulnerable Road Users

1 Titles seem clickable but are not

Home Add Vehicle Visualize FAQ

2 Carousel titles are hyperlinks, but not clear at all unless you hover

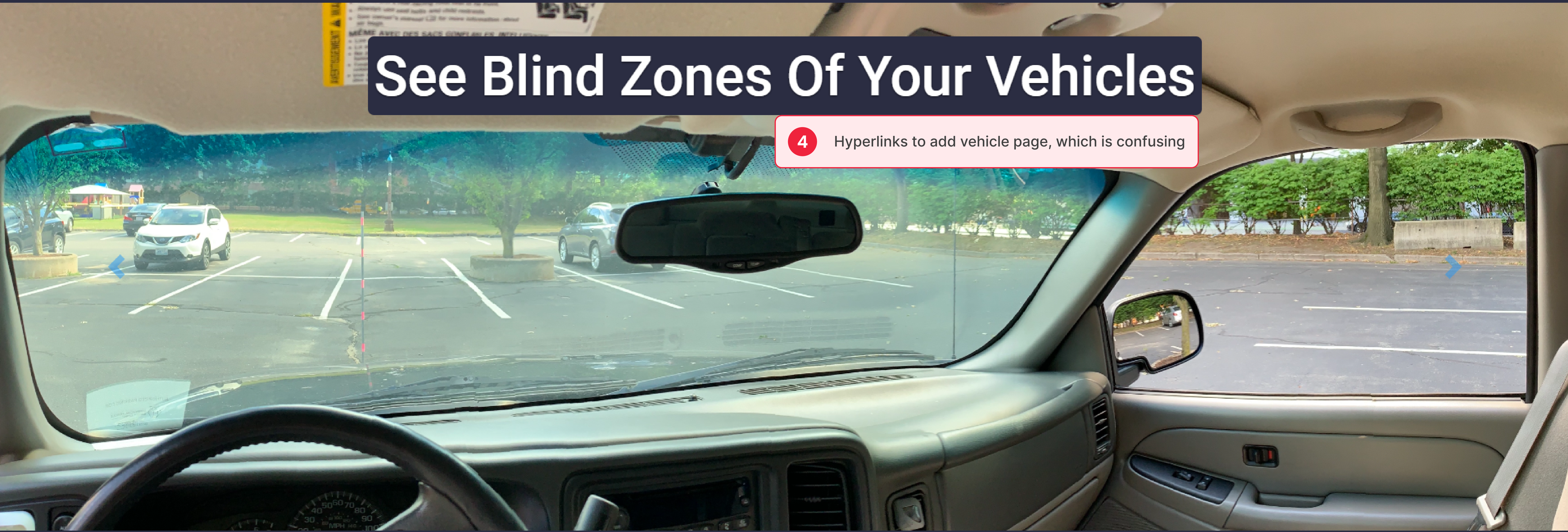
3 Hyperlinks to vehicle information for 2006 kenworth t800, which is confusing

Our Free, Smartphone-Based Blind Zone Measurement Tool Enables:

Compare and select the best-in-class direct vision makes and models

Understand the risks of blind zones

Discover how much can be seen from their vehicle and risk to Vulnerable Road Users



Our Free, Smartphone-Based Blind Zone Measurement Tool Enables:

Compare and select the best-in-class direct vision makes and models

Understand the risks of blind zones

Discover how much can be seen from their vehicle and risk to Vulnerable Road Users

Home Add Vehicle Visualize FAQ

Frequently Asked Questions

5 Images seem outdated

Our Free, Smartphone-Based Blind Zone Measurement Tool Enables:

Compare and select the best-in-class direct vision makes and models

Understand the risks of blind zones

Discover how much can be seen from their vehicle and risk to Vulnerable Road Users

Home Add Vehicle Visualize FAQ

6 No page title / indicator that we're on the 'Add Vehicle' page

The VIEW app measures vehicles' percent visibility from the driver's seat.

7 Can instructions be embedded on the page? Or is the use case to not need a computer / phone when measuring

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

1 PDF useful for printing instructions

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

8 Misleading title, video shows how to take a panoramic photo

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:

(Photo may take up to 10 seconds to load)

If using an unstable internet connection or a VPN, the photo might not be uploaded to our database. VIEW also works best on Chrome.

Choose File No file chosen

Home Add Vehicle Visualize FAQ

Direct Vision Comparison Table

The table below displays all vehicle entries in the VIEW app. The table will update based on inputs to the search bar and the range filter. Click the "Details" column to find more information about that particular vehicle.

Table may take a moment to load.

Frequently Asked Questions

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Visualize (loading)

9 Is a dropdown menu the best way to show this information? Calling this FAQ when there's a FAQs tab seems confusing. Can we show this information without a dropdown, expecially when the page is loading

Frequently Asked Questions

What does the table on the "Visualize" page show?

Each table row has data points for an individual vehicle entered into our database. Body class and weight class are convenient ways to separate vehicles by purpose - body class categories include passenger vehicles, SUVs, minivans, vans, pickup trucks, commercial trucks, and buses. Both data elements are usually populated by vehicle ID number (VIN) lookup when the vehicle is added to the database.

Why are there multiple entries for some vehicles?

The VIEW app is a crowdsourced database to which multiple different users can add data and can add multiple entries for the same make and model, tailored to their unique driving position and eyepoint in the vehicle. Multiple measurements can provide a distribution of blind zone size for unique vehicles and contribute to confidence in the results. Although most drivers will adjust their seats to a comfortable location that places their eyepoint in a similar location (as described by the SAE J941 eyellipse), VIEW app outputs are generally specific to the drivers performing the input process. For standardized measurements representative of the vehicle blind zone for a standardized driver size and seat position, a standardized camera rig may be used (see FAQ above).

Home Add Vehicle Visualize FAQ

Direct Vision Comparison Table

The table below displays all vehicle entries in the VIEW app. The table will update based on inputs to the search bar and the range filter. Click the "Details" column to find more information about that particular vehicle.

Table may take a moment to load.

10 'ID' column name is misleading for linking entry details

Show 10 **entries** **Search:**

11 There's a hover interaction when cursor is over the row, but only the details hyperlink is clickable

			Year	Body Class	Weight Class	ID
2023-09-20	HONDA	Odyssey	2011	N/A	Class 1	Details
2023-09-13	HONDA	CR-V	2010	N/A	Class 1	
2023-09-13	Honda	Odyssey	2011	N/A	Class 1	
2023-09-06	HONDA	Civic	2020	Passenger	Class 1	Details
2023-09-01	CHEVROLET	Suburban	2006	SUV	Class 2	Details
2023-09-01	CHEVROLET	Suburban	2006	SUV	Class 2	Details
2023-09-01	NISSAN	Altima	2019	Passenger	Class 1	Details
2023-09-01	CHEVROLET	Suburban	2006	SUV	Class 2	Details
2023-07-20	CHEVROLET	Suburban	2006	SUV	Class 2	Details
2023-07-20	CHEVROLET	Suburban	2006	SUV	Class 2	Details

12 'Details' opens in a new tab instead of the same page with breadcrumb to go back, which can cause too many pages to be open and extra work to close them

Showing 1 to 10 of 479 entries

Previous 1 2 3 4 5 ... 48 Next

Frequently Asked Questions

Vehicle Information

2006 KENWORTH T800

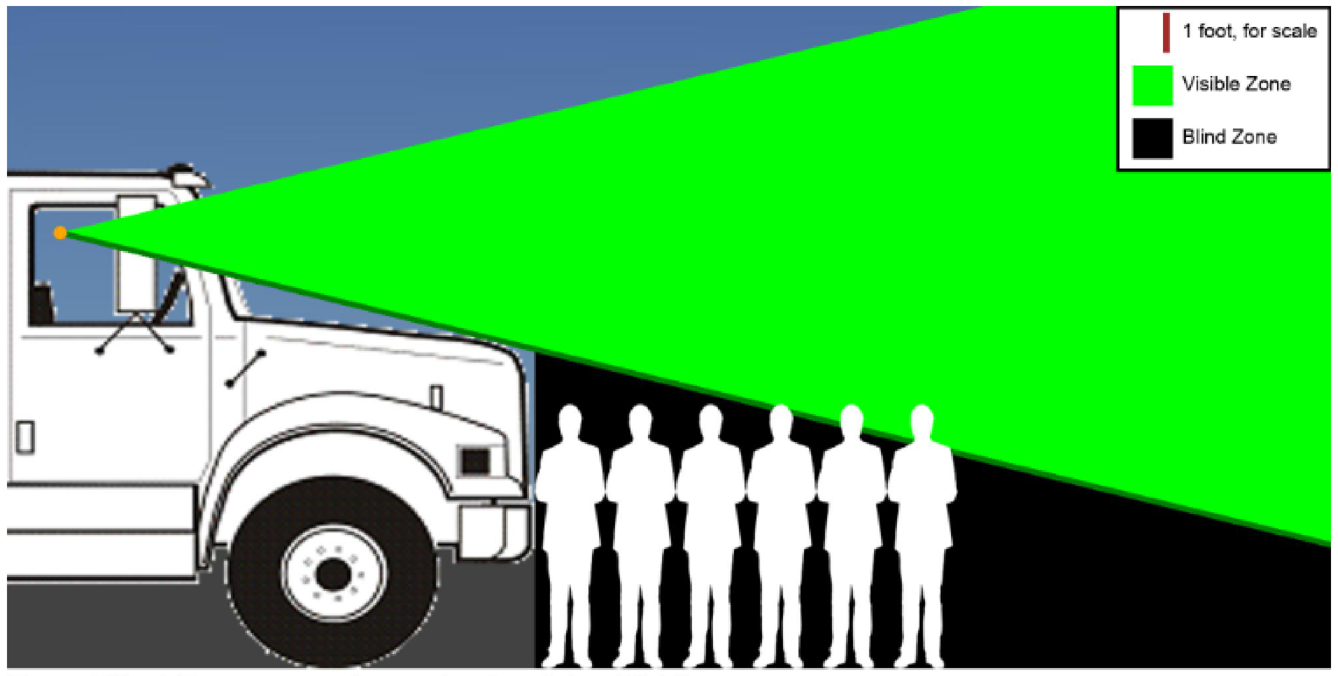
Vulnerable Road User:

Adult

13 No indicator that vulnerable user can be changed by the dropdown

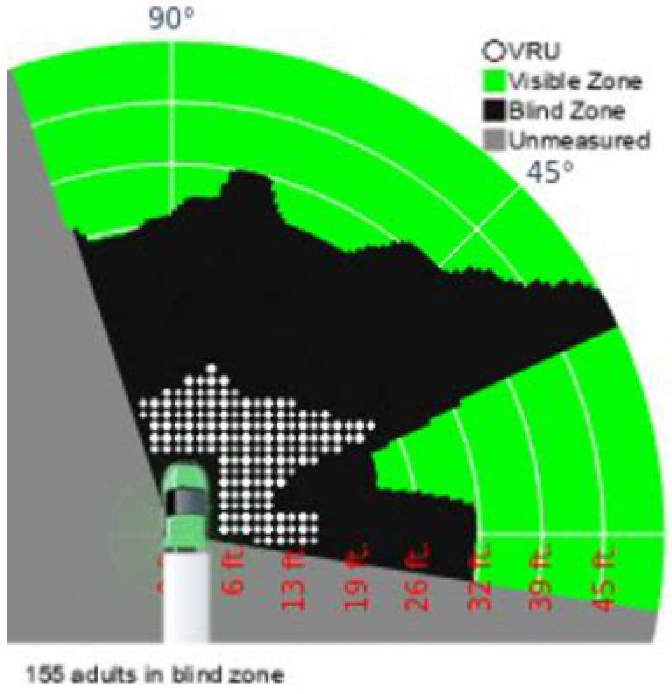
Images may take a few seconds to load upon choosing a VRU. Additionally, slow internet speeds may affect image generation.

Front Blindzone



Front Blind Zone extends out by 6 adults (8' 0")

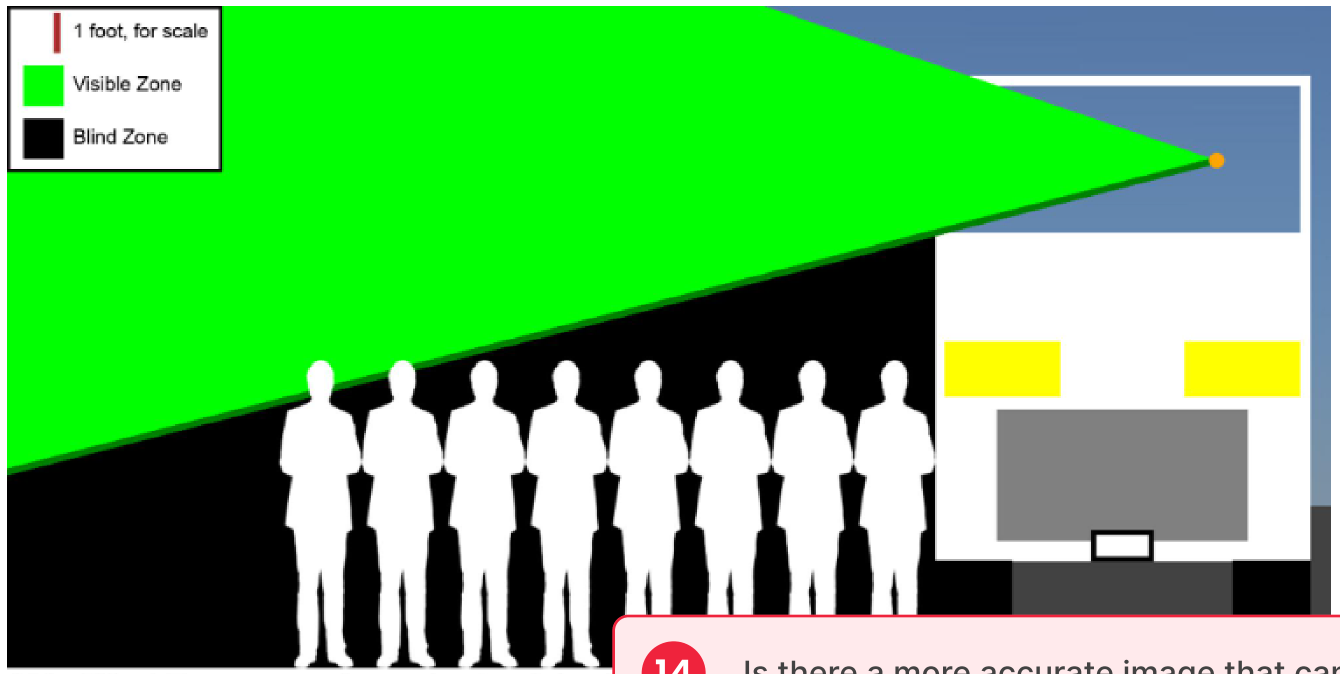
Overhead View of Blindzones



Panoramic Photo

15 Images can have more accompanying text to explain significance and relevance, and maybe tips or things to keep an eye out for

Passenger Side Blindzone



Side Blind Zone extends out by 8 adults (

14 Is there a more accurate image that can be used for front view of the car

Figure Notes:

A vulnerable road user is considered invisible if a driver cannot see their head. The calculations use the heights to the shoulders of 5th percentile United States female vulnerable road users. By VRU, the heights to shoulders are: preschool child 28 inches, elementary school child 37 inches, elementary school child on bicycle 35 inches, wheelchair user 39 inches, adult on bicycle 47 inches, adult 49 inches.

Home Add Vehicle Visualize FAQ

Frequently Asked Questions

16 FAQ title is inconsistent with Visualize page

About Us

Who are we?

What is our mission?

Direct Vision and Blindzones

What is direct vision?

Why is direct vision important?

What is a blind zone?

What is a Vulnerable Road User?

This Website

What is the VIEW app?

Who can use this website?

Is this a final version of the website?

Measurements

How is the number of vulnerable road users calculated?

Specific Pages

How do I add my vehicle to the database?

What does the table on the "Visualize" page show?

Why are there multiple entries for some vehicles?

17 (Specific pages: how do I add my vehicle to the database) Link to add vehicle page can be useful

Please contact blindzoneapp@dot.gov if you have any other questions or concerns, or if your organization is interested in working with us.

Home Add Vehicle Visualize FAQ

The VIEW app measures vehicles' percent visibility from the driver's seat.

1 These panels are not relevant to marking the image, and may detract from task at hand

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

2 Directions to upload image are still showing after image has been uploaded

Choose field of view panoramic image to upload:

(Photo may take up to 10 seconds to load)

Click to draw

2 Click to draw what? Would be helpful to show drawing instructions first

4 Why can users skip this step and click next without marking anything?

Back Clear Next

(Step 1 of 11):

1 Information about process status (what step out of how many) is useful for users, along with disabled button to go back.

Passenger Vehicle & Light Truck Tracing Example:

Heavy Truck Tracing Example:

2 Image examples are very helpful, but might be better to place under the instructions

If the 1 foot mark (M1) is visible on the measurement pole, use your finger or your mouse to draw a small horizontal line on the mark. After making a line on the mark, hit next. If the mark is not visible, click next. Press clear if any errors are made.

5 Copy can be clearer: "Press clear to redraw marking"

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions
Vehicle measurement and panoramic photo instructions.

Recording Sheet
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Adding a Vehicle
First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:
(Photo may take up to 10 seconds to load)

Click to draw

Back Clear Next

6 Unclear if users can skip this step since 'Next' button is not disabled

(Step 6 of 11):

Passenger Vehicle & Light Truck Tracing Example:

Heavy Truck Tracing Example:

Draw a vertical line at 0 degrees (directly in front of the driver where the measuring stick was placed).

7 UX copy saying "draw a line over the measuring stick" may be more useful than "at 0 degrees"

Marking Tips:
- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions
Vehicle measurement and panoramic photo instructions.

Recording Sheet
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Adding a Vehicle
First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:
(Photo may take up to 10 seconds to load)

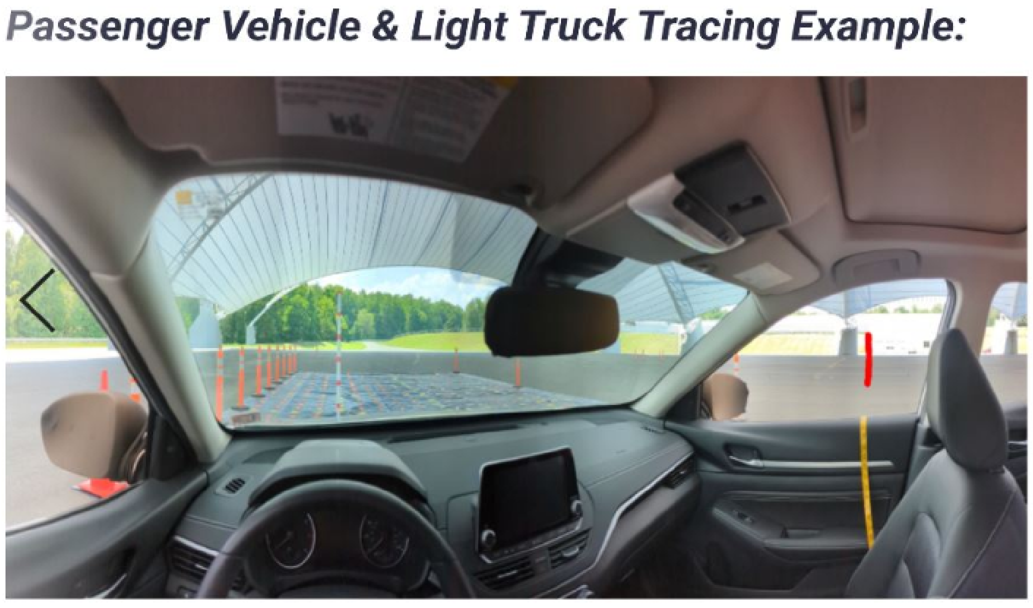
Click to draw

Back Clear Next

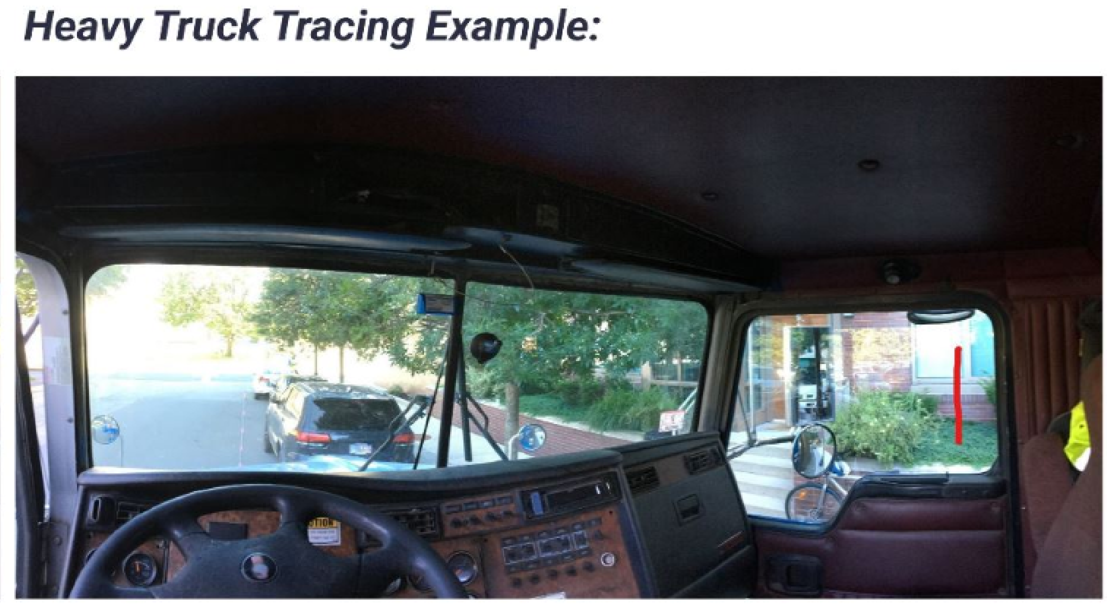
8 Unclear if users can skip this step since 'Next' button is not disabled

(Step 7 of 11):

Passenger Vehicle & Light Truck Tracing Example:



Heavy Truck Tracing Example:



Draw vertical line at 90 degrees (directly to the right of the driver out of passenger window).

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:

(Photo may take up to 10 seconds to load)

Click to draw

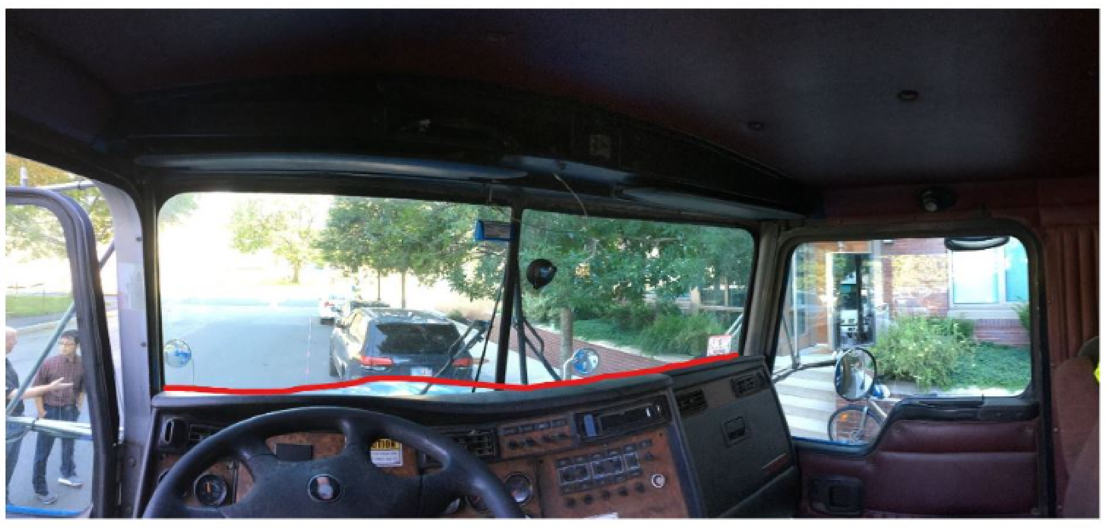
Back Clear Next

9 Unclear if users can skip this step since 'Next' button is not disabled

(Step 8 of 11):

Passenger Vehicle & Light Truck Tracing Example:

Heavy Truck Tracing Example:



Draw line along the bottom of the front field of view. Please make sure that there are as few unintended gaps between dots as possible.

9 Why are there dots in the first place? Could we replace with a solid line? If not, add tips to avoid dots (like draw slowly)

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Thank you. Your vehicle was added to the vehicle database. You can access the database on the 'Vehicle Database' page.

16 'Vehicle Database' page does not exist, should be changed to "Visualize"

Vehicle Make:

HONDA

Vehicle Model:

Odyssey

Vehicle Year:

2011

Vehicle Weight Class:

Class 1: <6,000 lbs (Ex: Most Passenger Cars)

Back Clear Next

15 Buttons are not relevant anymore and doesn't need to be displayed

Home Add Vehicle Visualize FAQ

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

(Step 11 of 11): In order to add to the vehicle database, would you like to add your vehicle using the VIN number, or the vehicle make, model, year, and weight class? (Choose one):

VIN Number ○

Make, Model, Year, Weight Class ◉

Vehicle Make:

HONDA

Vehicle Model:

Odyssey

Vehicle Year:

2011

Vehicle Weight Class:

Class 1: <6,000 lbs (Ex: Most Passenger Cars)

General Comments:

Comments

Agency:

Agency

Optional field, for agencies to keep track of their vehicle entries.

Back Clear Next

13 No disabled buttons state

14 Would be clearer to say “Finish” instead of ‘Next’ to indicate they are submitting their information

Home Add Vehicle Visualize FAQ

The VIEW app measures vehicles' percent visibility from the driver's seat.

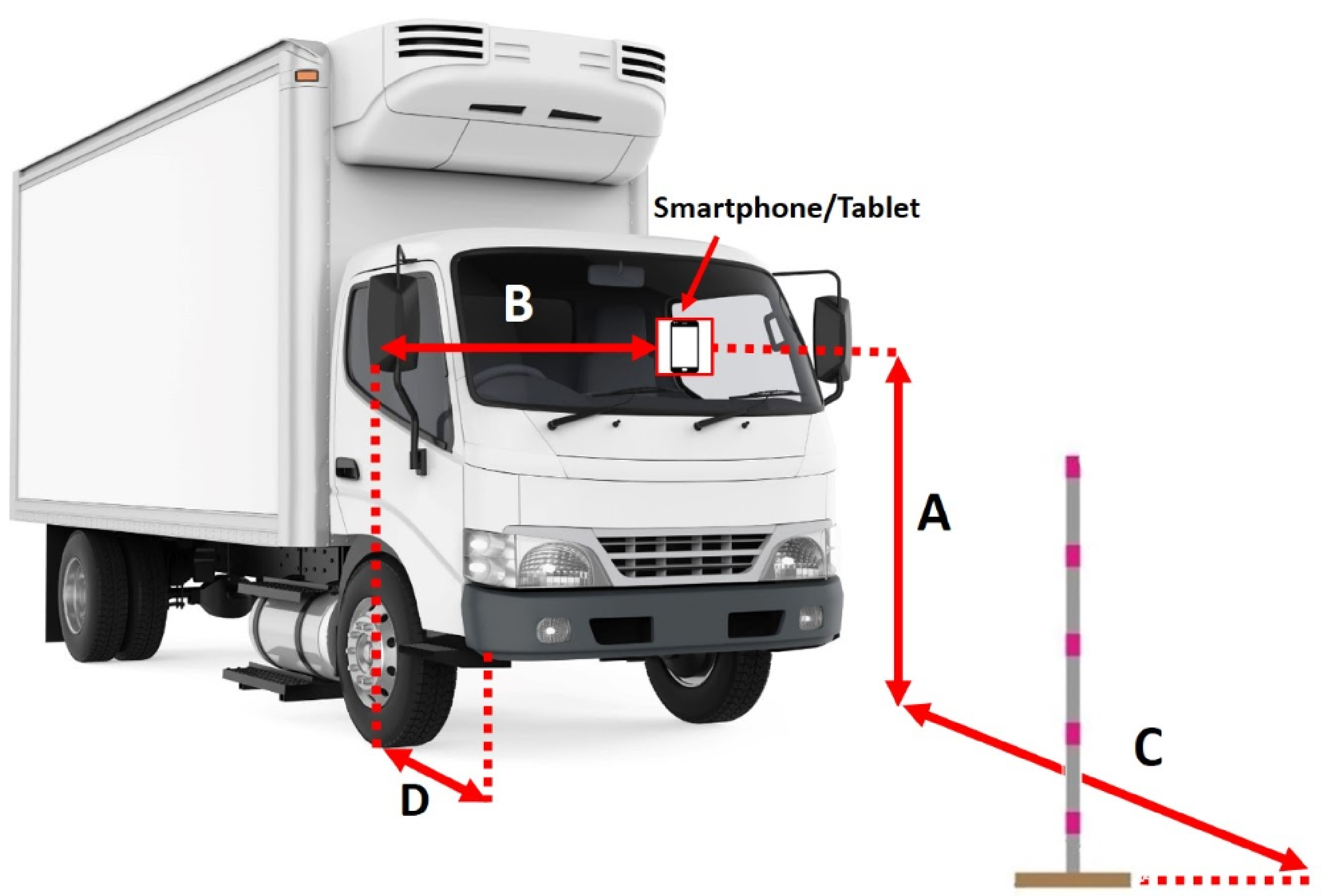
Measurement Instructions
Vehicle measurement and panoramic photo instructions.

Recording Sheet
Print-off version of vehicle measurement sheet.

Adding a Vehicle
First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

(Step 10 of 11): Enter vehicle measurements A, B, C, and D. All values should be positive.



Choose your input units:

Inches ◉

Centimeters ○

Camera height (or driver's eye height) above ground:

57

Measurement 'A' in reference image above. The range of valid values is 24 - 324 in or 61 - 823 cm.

Distance from drivers's eye/camera to passenger window:

44

Measurement 'B' in reference image above. The range of valid values is 24 - 126 in or 61 - 320 cm.

Distance from driver to measurement stick:

246

Measurement 'C' in reference image above. This is not the hypotenuse, but the distance along the ground. The range of valid values is 12 - 1200 in or 30 - 3048 cm.

Distance from driver's eye/camera to front bumper of vehicle:

87

Measurement 'D' in reference image above. The range of valid values is 1 - 192 in or 2 - 488 cm. This value must be smaller than measurement 'C'.

Back Clear Next

12 No error message when input values are outside of range, just shows a disabled 'Next' button

The VIEW app measures vehicles' percent visibility from the driver's seat.

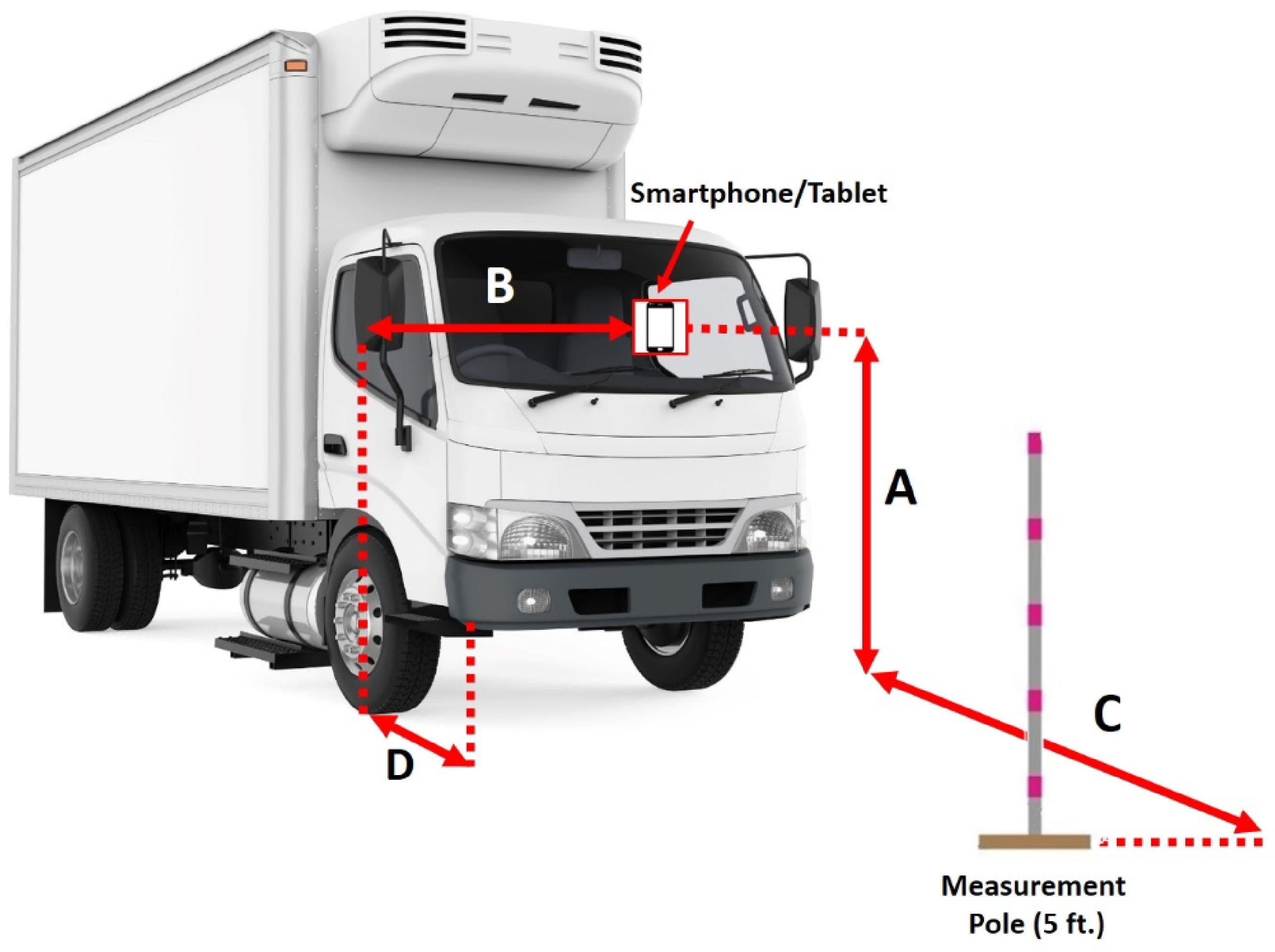
Measurement Instructions
Vehicle measurement and panoramic photo instructions.

Recording Sheet
Print-off version of vehicle measurement sheet.

Adding a Vehicle
First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

(Step 10 of 11): Enter vehicle measurements A, B, C, and D. All values should be positive.



Choose your input units:

Inches ◉

Centimeters ○

5 Placeholder text

Camera height (or driver's eye height) above ground:

Enter height eg: 63

Measurement 'A' in reference image above. The range of valid values is 24 - 324 in or 61 - 823 cm.

11 Range of values was easily skipped over, and maybe be useful to include with the textbox header

Distance from drivers's eye/camera to passenger window:

Enter distance eg: 45

Measurement 'B' in reference image above. The range of valid values is 24 - 126 in or 61 - 320 cm.

Distance from driver to measurement stick:

Enter distance eg: 94

Measurement 'C' in reference image above. This is not the hypotenuse, but the distance along the ground. The range of valid values is 12 - 1200 in or 30 - 3048 cm.

Distance from driver's eye/camera to front bumper of vehicle:

Enter distance eg: 84

Measurement 'D' in reference image above. The range of valid values is 1 - 192 in or 2 - 488 cm. This value must be smaller than measurement 'C'.

Back Clear Next

10 Buttons changed location from previous steps

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:

(Photo may take up to 10 seconds to load)

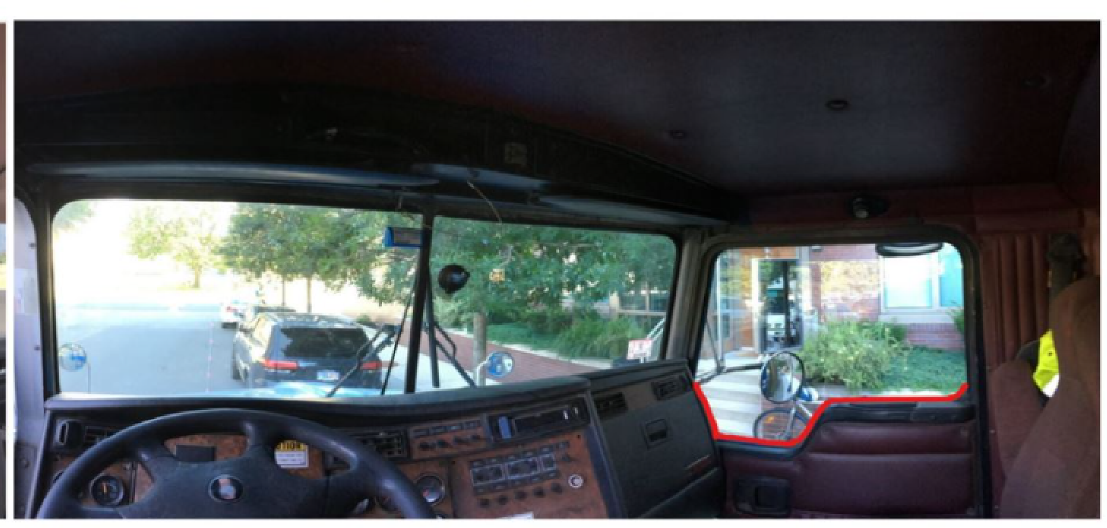
Click to draw

Back Clear Next

(Step 9 of 11):

Passenger Vehicle & Light Truck Tracing Example:

Heavy Truck Tracing Example:



Draw line along the bottom of the passenger side field of view. Be sure to draw above the sideview mirror. Please make sure that there are as few unintended gaps between dots as possible.

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

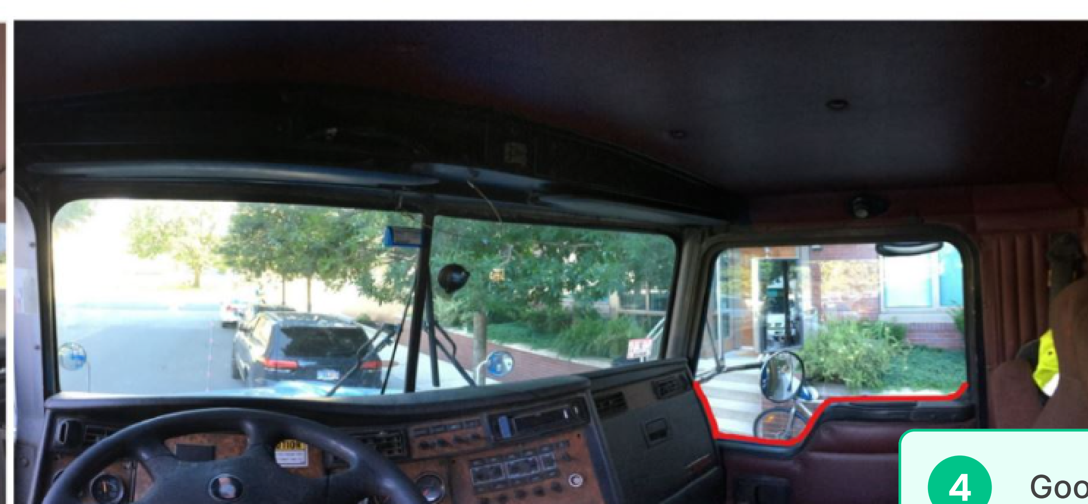
Choose field of view panoramic image to upload:
(Photo may take up to 10 seconds to load)

Click to draw

Back Clear Next

(Step 9 of 11):

Passenger Vehicle & Light Truck Tracing Example: ***Heavy Truck Tracing Example:***



4 Good callout for side windows

Draw line along the bottom of the passenger side field of view. Be sure to draw above the sideview mirror. Please make sure that there are as few unintended gaps between dots as possible.

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

Home Add Vehicle Visualize FAQ

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:

(Photo may take up to 10 seconds to load)

If using an unstable internet connection or a VPN, the photo might not be uploaded to our database. VIEW also works best on Chrome.

Choose File No file chosen

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:

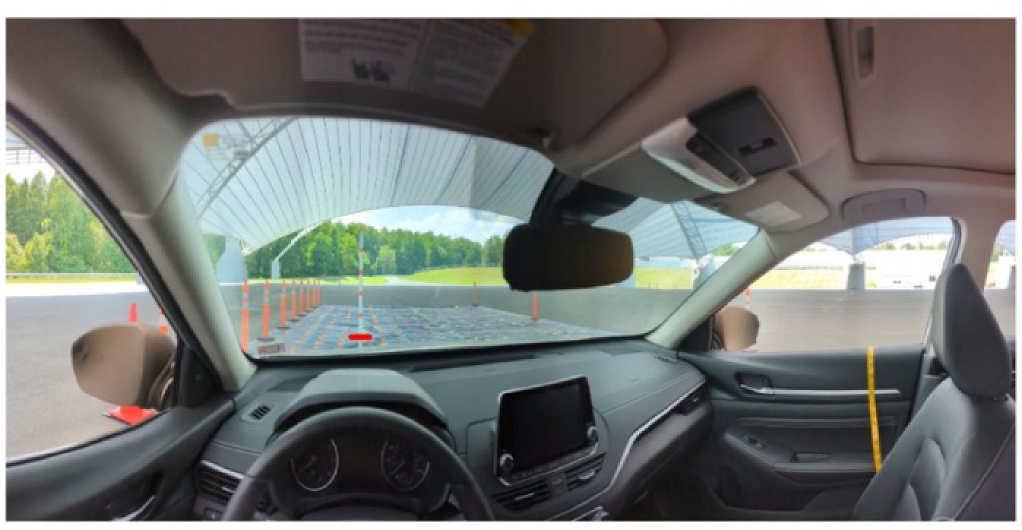
(Photo may take up to 10 seconds to load)

Click to draw

Back Clear Next

(Step 1 of 11):

Passenger Vehicle & Light Truck Tracing Example:



Heavy Truck Tracing Example:

If the 1 foot mark (M1) is visible on the measurement pole, use your finger or your mouse to draw a small horizontal line on the mark. After making a line on the mark, hit next. If the mark is not visible, click next. Press clear if any errors are made.

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions
Vehicle measurement and panoramic photo instructions.

Recording Sheet
Print-off version of vehicle measurement sheet.

Adding a Vehicle
First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

Choose field of view panoramic image to upload:
(Photo may take up to 10 seconds to load)

Click to draw

Back Clear Next

(Step 2 of 11):

Passenger Vehicle & Light Truck Tracing Example:

Heavy Truck Tracing Example:

If the 2 foot mark (M2) is visible on the measurement pole, use your finger or your mouse to draw a small horizontal line on the mark. After making a line on the mark, hit next. If the mark is not visible, click next. Press clear if any errors are made.

Marking Tips:

- Try to be as accurate as possible with your measurements and panoramic photo scan.
- Turn phone horizontally for best results.
- Pan/zoom in the white space outside of the image.

The VIEW app measures vehicles' percent visibility from the driver's seat.

Measurement Instructions

Vehicle measurement and panoramic photo instructions.

Recording Sheet

Print-off version of vehicle measurement sheet.

Adding a Vehicle

First time user video walkthrough of how to add a vehicle.

For a condensed version of the measurement instructions, click here.

(Step 11 of 11): In order to add to the vehicle database, would you like to add your vehicle using the VIN number, or the vehicle make, model, year, and weight class? (Choose one):

VIN Number ○

Make, Model, Year, Weight Class ○

General Comments:

Comments

Agency:

Agency

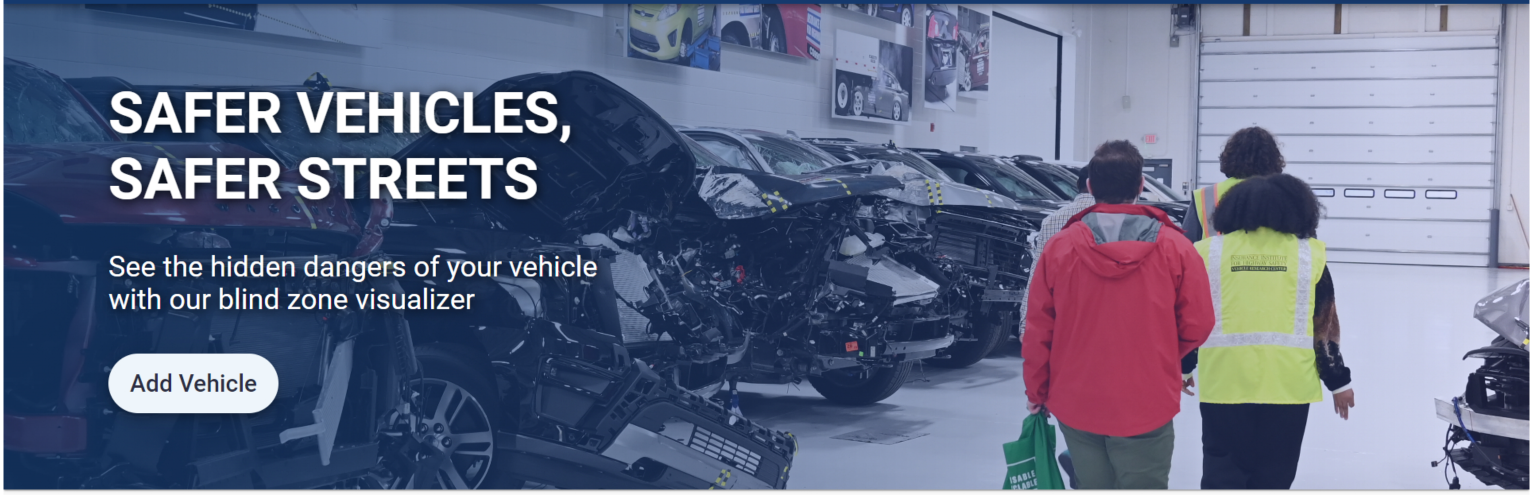
Optional field, for agencies to keep track of their vehicle entries.

Back Clear Next

Appendix N – VIEW 2.0 Site Screenshots

VIEW Blind Zone Calculator

Home | Vehicle Database | FAQ | Add Vehicle



SAFER VEHICLES, SAFER STREETS

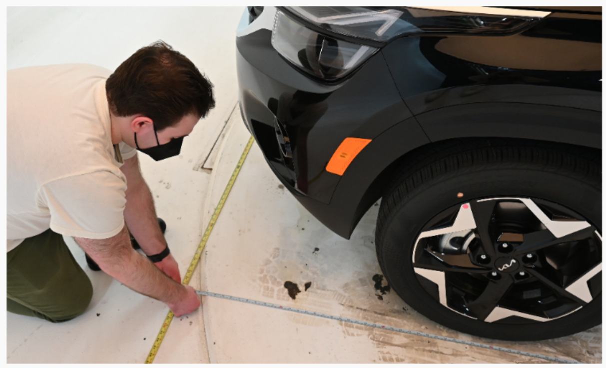
See the hidden dangers of your vehicle with our blind zone visualizer

Add Vehicle

About VIEW

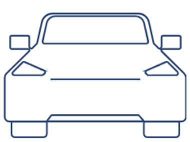
A free blind zone measurement tool

VIEW is a measurement tool and crowd-sourced database with visualizations of blind-zones for many types of vehicles. It uses LiDAR technology and seat measurements to calculate what space around the vehicle is visible from the driver's eyepoint.



Who It Helps

VIEW is designed to help all kinds of people



Vehicle Buyers

Discover blind-zones to help make purchase decisions.

Fleet Managers

Measure and address blind zones in vehicles on the road.

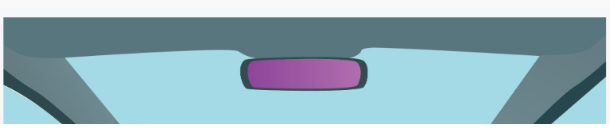
Organizations

Access blind-zone information to raise awareness.

Why This Matters

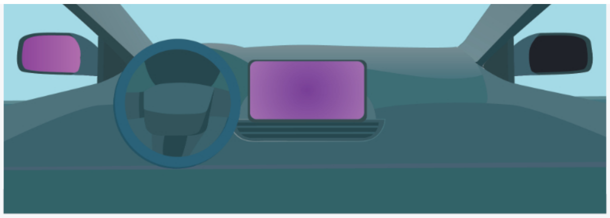
Research shows that drivers respond 0.7 seconds faster to hazards seen through direct vision than indirect vision. In addition, according to a study conducted at the University of Leeds, drivers react up to 50% faster to hazards in their direct vision compared to indirect vision.

Learn More



Indirect Vision

What a driver can see with the aid of devices such as mirrors and cameras.



Blind Zone

Where visibility is blocked by solid components of the vehicle.

Direct Vision

What a driver can see directly with their own eyes.

Who We Are

About Us

We are a group of safety researchers and professionals at the U.S. DOT Volpe Center focused on addressing the rising number of pedestrian and bicyclist fatalities.

In partnership with Federal and non-Federal stakeholders, we aim to quantify and understand the safety impacts of large blind zones and to inform Safe System Approach solutions to save lives.

Curious to learn more?

Find answers to frequently asked questions about the work we do, vehicle blind-zones, and how to use the site.

FAQs

Contact Us:
blindzoneapp@dot.gov

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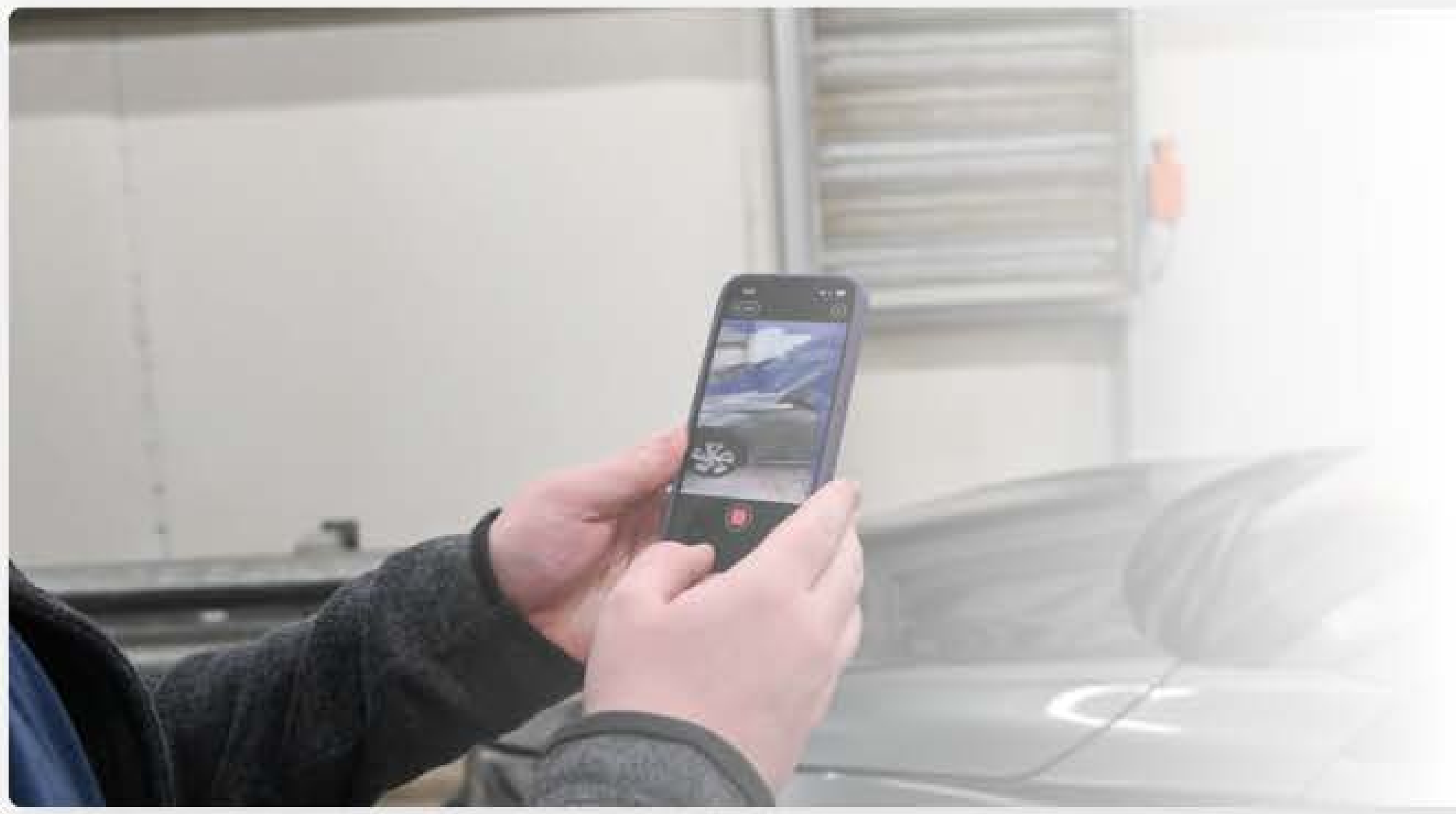
Add a Vehicle

The VIEW blind zone calculator uses LiDAR scans of a vehicle, along with vehicle and eye point measurements, to calculate and visualize blind zones. Our system is compatible with LiDAR-capable (Pro) iOS devices running the Polycam app.

To add a new vehicle, you will need access to the vehicle, a LiDAR-capable (Pro) iOS device, and a tape measure. Before taking a measurement, please download Polycam from the App Store.



Collect Data

Take measurements of the seat position and scan the exterior of your vehicle using LiDAR in the Polycam app.

View Instructions

Upload Data

Once you've collected measurements, add your vehicle information, measurements, and LiDAR scan for processing.

Get Started

Contact Us:

blindzoneapp@dot.gov

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Measurement & Scanning Instructions

Instructions PDF

Materials Needed

- Pro iOS device (iPhone 12 Pro/iPad Pro 4th gen or newer)
- Polycam app (download on the App Store)
- Selfie stick (optional, only required if measuring vehicles larger than vans)
- 8+ foot tape measure (2x recommended)
- Removable tape (ex: painter's or masking tape, sticky notes)

Note General Vehicle Information

When adding a vehicle to the VIEW database, you will be asked to provide general information about the vehicle:

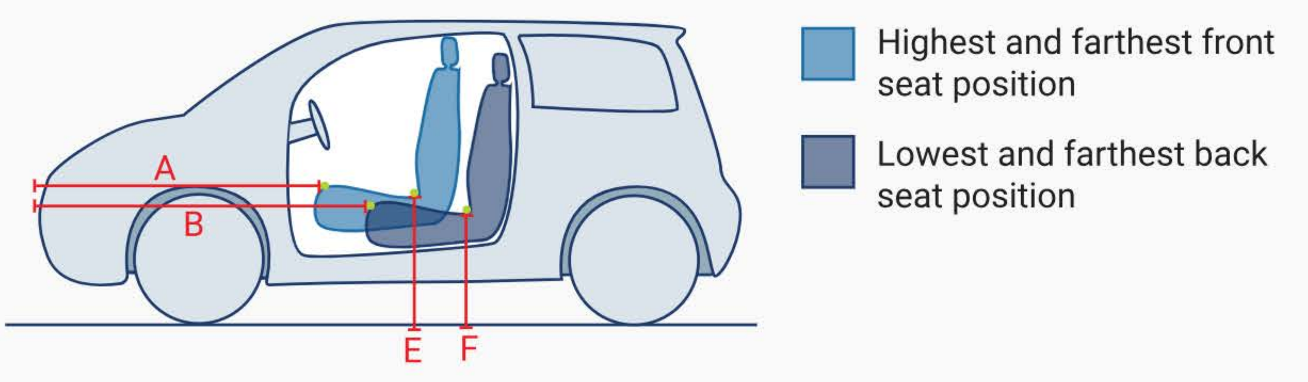
- **Make**
- **Model**
- **Year***
- **Body class****
- **Weight class*****

If you do not know the make, model, or year of your vehicle, you can find this information in the manual or by looking up the vehicle's VIN or license plate number.

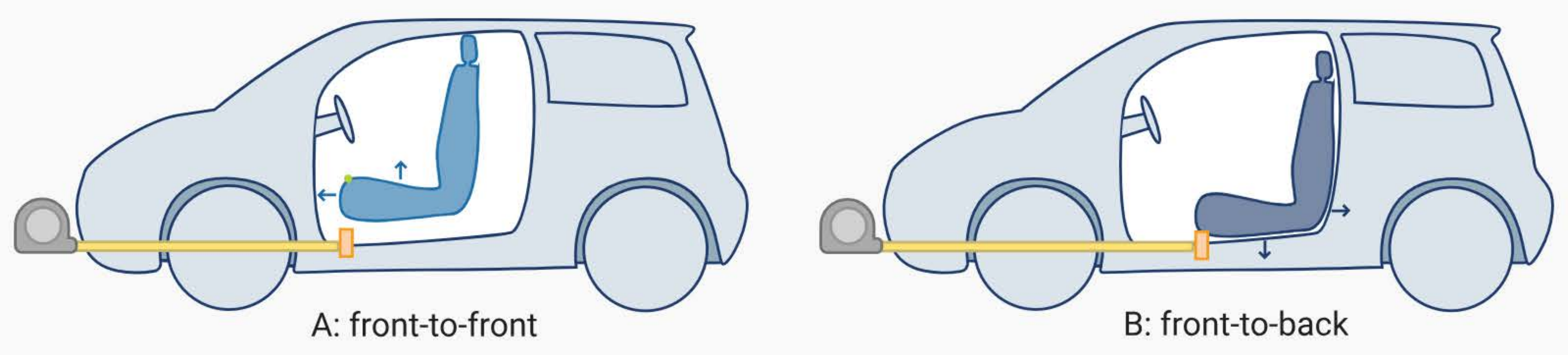
**Vehicle year refers to the model year, not the year of manufacture/purchase. Vehicles may be sold with a model year beyond the year of sale (ex: a 2012 model year sold in late 2011). Confirm the model year of your vehicle before submitting an entry.*
***Body class refers to the US Federal Highway Administration (FHWA) vehicle body classification system. (https://www.fhwa.dot.gov/policyinformation/tmguide/tmg_2013/vehicle-types.cfm)*
****Weight class refers to the US Federal Highway Administration (FHWA) vehicle weight classification system. Passenger vehicles are generally class 1. (https://afdc.energy.gov/data/10380)*

Measure Vehicle

The first step of collecting data to create visualizations using the VIEW blind zone measurement tool is to measure the upper and lower bounds of the driver's seat adjustment in relation to the front of the vehicle and the ground. Having two people and an extra tape measure will simplify the measurement process.

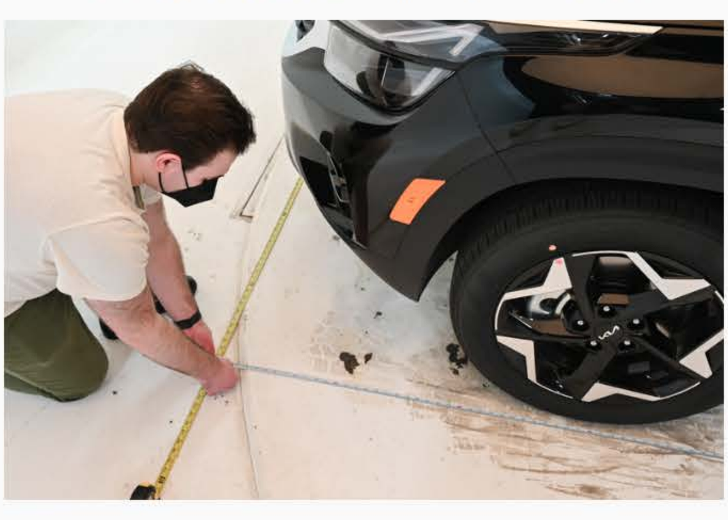


Part 1- Front of driver's seat to the front of vehicle hood

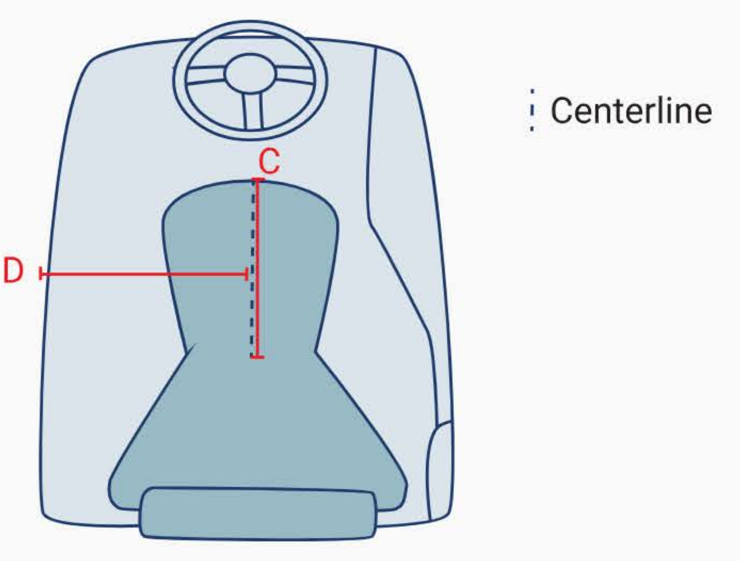


1. Adjust the driver's seat to the highest and farthest forward position
   - Use tape to mark the location of the front of the seat on the side of the vehicle
2. Adjust the driver's seat to the lowest and farthest back position
   - Use tape to mark the location of the front of the seat on the side of the vehicle

3. Using a tape measure, measure the distance along the side of the vehicle between the front of the hood and each tape marking. If you have a second tape measure, it can be used as a guide to aid in finding the front of the hood when measuring along the side of the vehicle. Run the second tape measure along the width of the vehicle in line with the hood, then run the first tape measure to the guide.



- Note these measurements as "**A: front-to-front**" and "**B: front-to-back**"



Part 2- Driver's seat depth

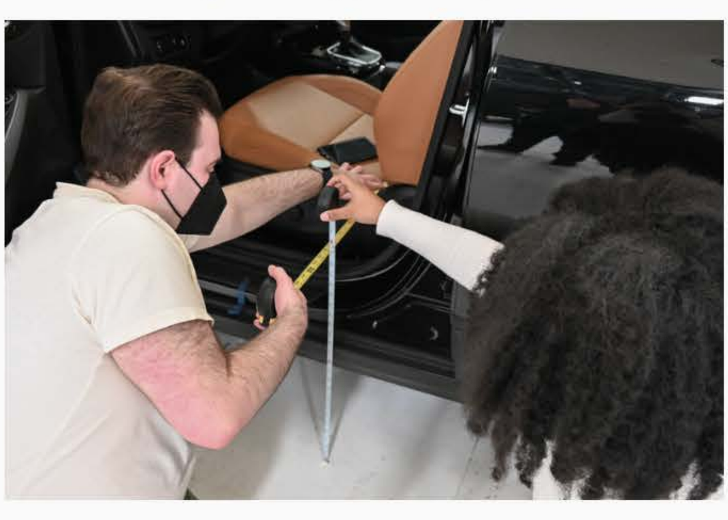
1. Measure along the driver's seat centerline from the front of the seat to the farthest back point where you can sit
   - Note this measurement as **"C: seat depth"**

Part 3- Driver's seat center

1. Measure from the centerline of the driver's seat to the outermost point of the vehicle on the driver's side. If you have a second tape measure, it can be used as a guide to form a line between the outermost point of the vehicle and the tape measure coming out from the seat.
   - Note this measurement as **"D: seat center"**

Part 4- Driver's seat height

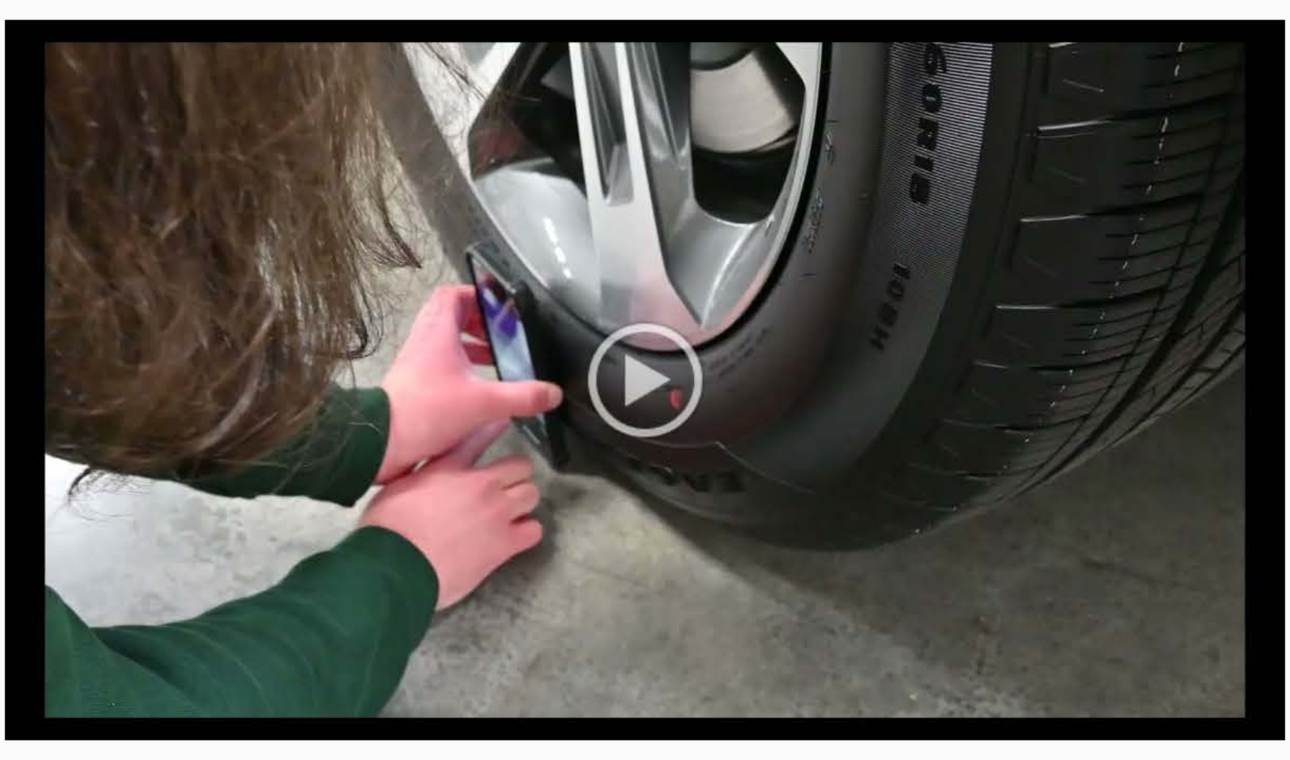
1. With the seat at its highest height, measure from the top of the seat, at its deepest point, to the ground. If you have a second tape measure, it can be used as a guide by lining it up with the seat cushion and flexing around any plastic components of the seat.



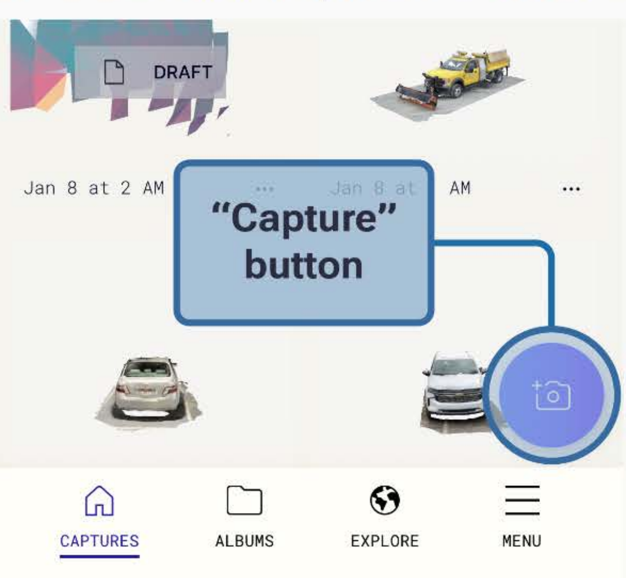
   - Note this measurement as **"E: seat high"**
2. With the seat at its lowest height, measure from the top of the seat, at its deepest point, to the ground. You may need to shift the seat forward to reach the back of the seat cushion for measurement. If you have a second tape measure, it can be used as a guide by lining it up with the seat cushion and flexing around any plastic components of the seat.
   - Note this measurement as **"F: seat low"**

Collect a LiDAR Scan

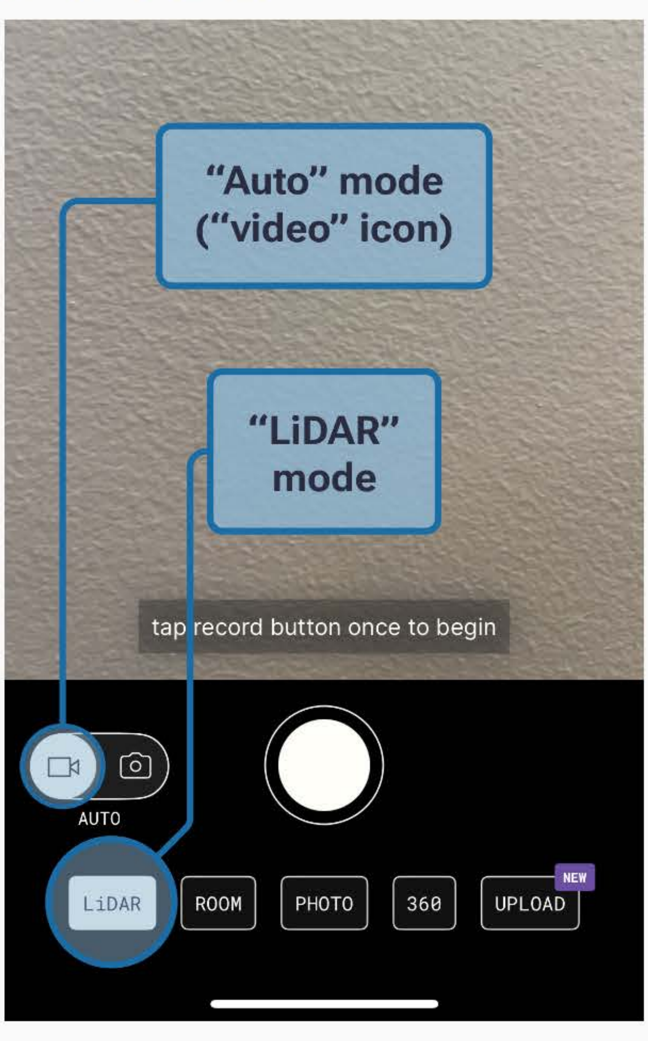
The second step of collecting data is to use your mobile device to create a 3D scan of your vehicle using Light Detection and Ranging (LiDAR).



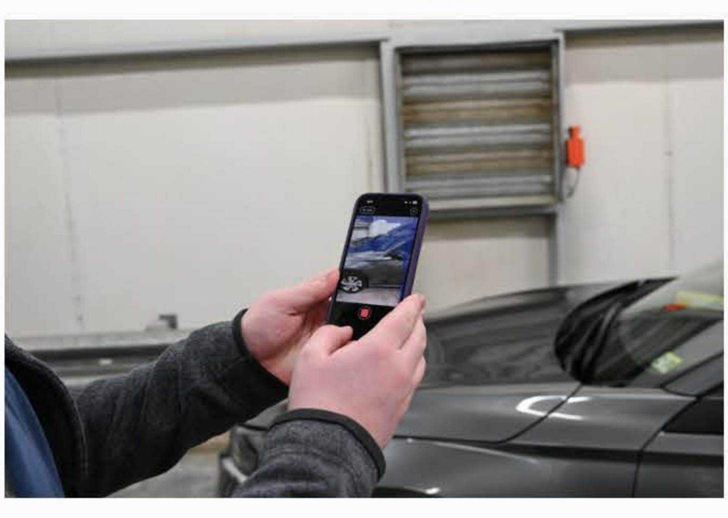
1. Download the Polycam app from the App Store
2. Open the app and hit skip on anything that asks you to pay for a subscription (you may need to set up an account, but you can do this for free)
3. From the home page of the app, press the camera button on the bottom right (if you are already in the camera section, ignore this step)



4. In the camera, make sure both video mode and LiDAR mode are selected



5. Align the phone with the axes of the car with the screen facing you. The easiest way to do this is to set it up against a rear wheel, making sure that the phone is still vertical (see the LiDAR Scan Process video for reference)
6. While the phone is aligned, press the record button to start the scan
7. Slowly move away from the wheel and begin the scan process. Move slowly up and down while walking around the car, making sure to fill in any blue gaps. Take your time – if you are too fast, the scan will become so far off that the app cannot fix it.



8. Once done, hit the record button again to stop the scan
9. You will be brought to a page with a rudimentary scan of the vehicle. Press the "process" button in the bottom right to process your scan. Depending on the size of the vehicle, this can take anywhere from ~30 seconds to a few minutes. Once the scan has processed, you may see a popup asking you to subscribe or pay for the service. Close out of the popup, as you do not need to subscribe.
10. Press the download button on the top right of the screen (not the upload button) to save your scan. The only option available for free users is GLTF. Use this. You may now send the file wherever you would like for ease of uploading to the blind zone measurement tool.

Add a Vehicle

Step 1/2 - Upload Data

General Vehicle Information

Body Class: N/A

Weight Class (if passenger vehicle, choose Class 1): Class 1

Make (brand): Toyota

Model: Corolla

Year: 2015

Vehicle Measurements

On which side of the vehicle did you start your LiDAR scan? Driver Side

A: Front-to-front (distance from front of hood to front of driver's seat at forward-most position): 0 ft 0 in

B: Front-to-back (distance from front of hood to front of driver's seat at backward-most position): 0 ft 0 in

C: Seat depth (distance from front of driver's seat to the furthest point back where you can sit): 0 ft 0 in

D: Seat center (distance from centerline of driver's seat to outermost point of vehicle on driver's side): 0 ft 0 in

E: Seat high (distance from top of driver's seat at its uppermost position to the ground): 0 ft 0 in

F: Seat low (distance from top of driver's seat at its lowest position to the ground): 0 ft 0 in

Upload LiDAR Scan

Scan your vehicle in Polycam, making sure to capture the front and sides of the vehicle up to the B pillar (just behind the front door) on either side. Export your scan as a GLTF (.glb) file on your device.

Choose File No file chosen

Cancel Upload Data

Contact Us:
blindzoneapp@dot.gov

Add a Vehicle

Step 2/2 - Remove Windshield

Erase Windshield Instructions

In the 3D file viewer below, use the eraser tool to remove the windshield from your vehicle scan. Erasing the windshield requires a mouse or touchpad.

Erase

Toggle Eraser Mode on and off by clicking the Erase/Move button. While in Eraser Mode, click and drag to erase.

Rotate Vehicle

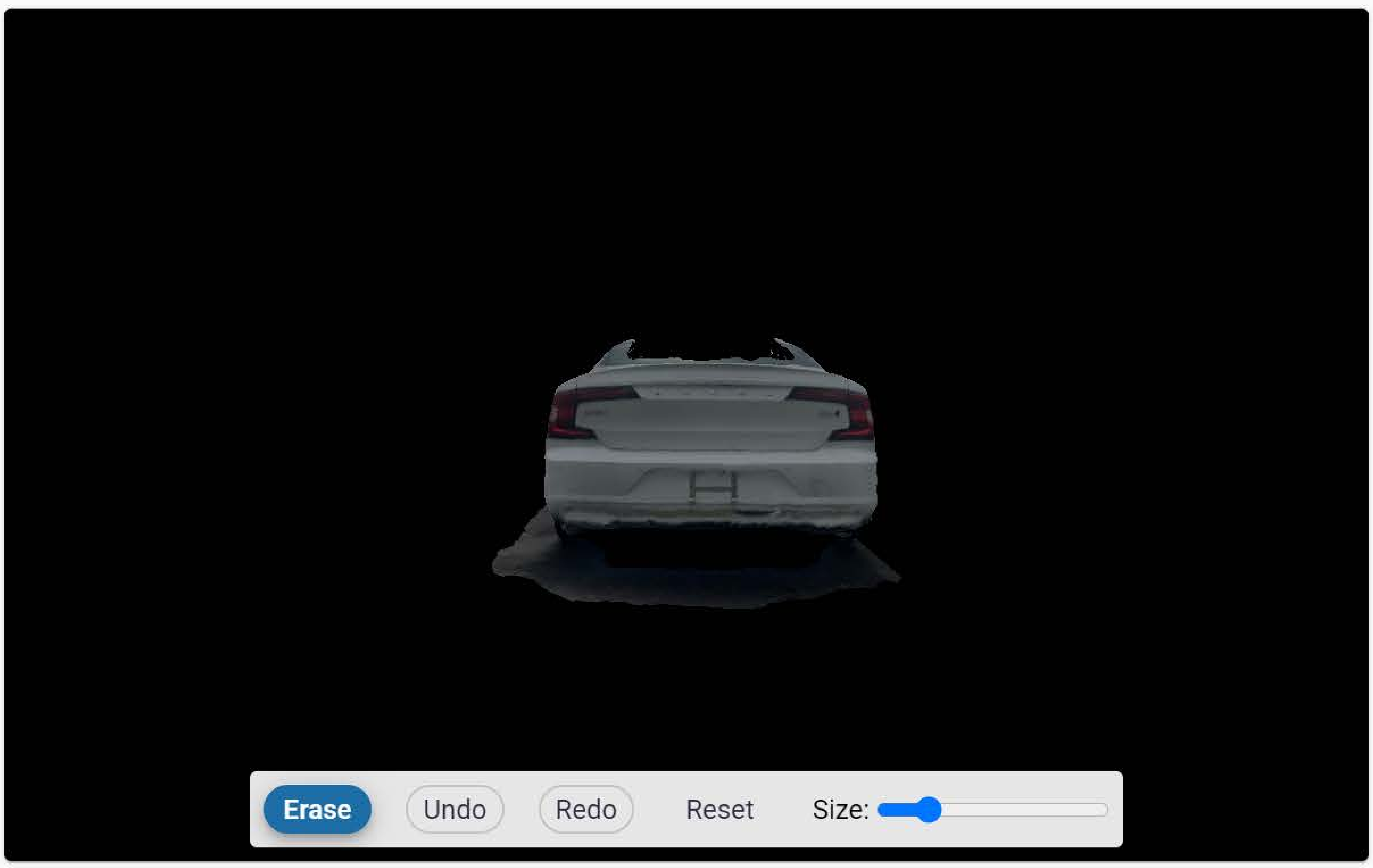
Make sure you are not in Eraser Mode. Click and drag to rotate vehicle.

Move/Translate Vehicle

Make sure you are not in Eraser Mode. Hold down the CTRL key while clicking and dragging to move the vehicle (left, right, up, diagonal, etc.).

Zoom In/Out

Make sure you are not in Eraser Mode. Scroll or pinch to zoom.



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Submit Entry

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VIEW Blind Zone Calculator

Home Vehicle Database FAQ Add Vehicle

Vehicle Database

Our database displays all vehicle entries on VIEW that are contributed by the public and by researchers. Explore the database to see all the vehicle information available and click View to see blind-zone visualizations and additional safety metrics.

Model | Search for Model | Clear

Entries Shown: 25

Sort By: Updated (New-Old)

Updated	Make	Model	Year	Body Class	Weight Class	Scan Details
2024-04-17	Chevrolet	Trax	2024	Passenger Cars	Class 1	2024-04-17 View
2024-04-17	Nissan	Altima	2024	Passenger Cars	Class 1	No Associated Scans
2024-04-17	Kia	Seltos	2024	Passenger Cars	Class 1	2024-04-17 View
2024-04-17	Honda	Odyssey	2011	Passenger Cars	Class 1	2024-04-17 View

Showing 1-4 of 4 entries

<< First < Previous 1 Next > Last >>

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2011 Honda Odyssey (April 17, 2024, 10:29 a.m. UTC)

Blindzone Visualizations

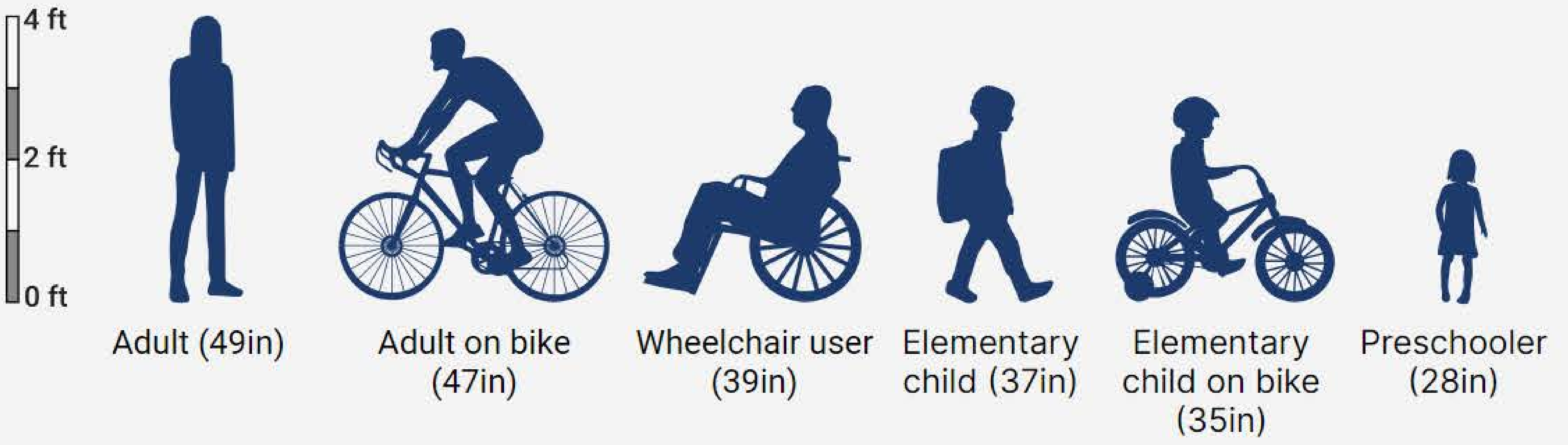
Choose a Driver Height

- ○ 5th-Percentile Female (60 inches)
- ● 50th-Percentile Male (69 inches)
- ○ 95th-Percentile Male (74 inches)

Choose 1-2 Vulnerable Road Users (VRUs)

- ☐ Preschool child (28 inches)
- ☑ Elementary school child on bicycle (35 inches)
- ☐ Elementary school child (37 inches)
- ☐ Wheelchair user (39 inches)
- ☐ Adult on bicycle (47 inches)
- ☐ Adult (49 inches)

*Vulnerable Road Users include pedestrians, cyclists, and people who use wheelchairs. A vulnerable road user is considered invisible if a driver cannot see their head. The calculations use the heights to the shoulders of 5th percentile United States female vulnerable road users.



Visualize

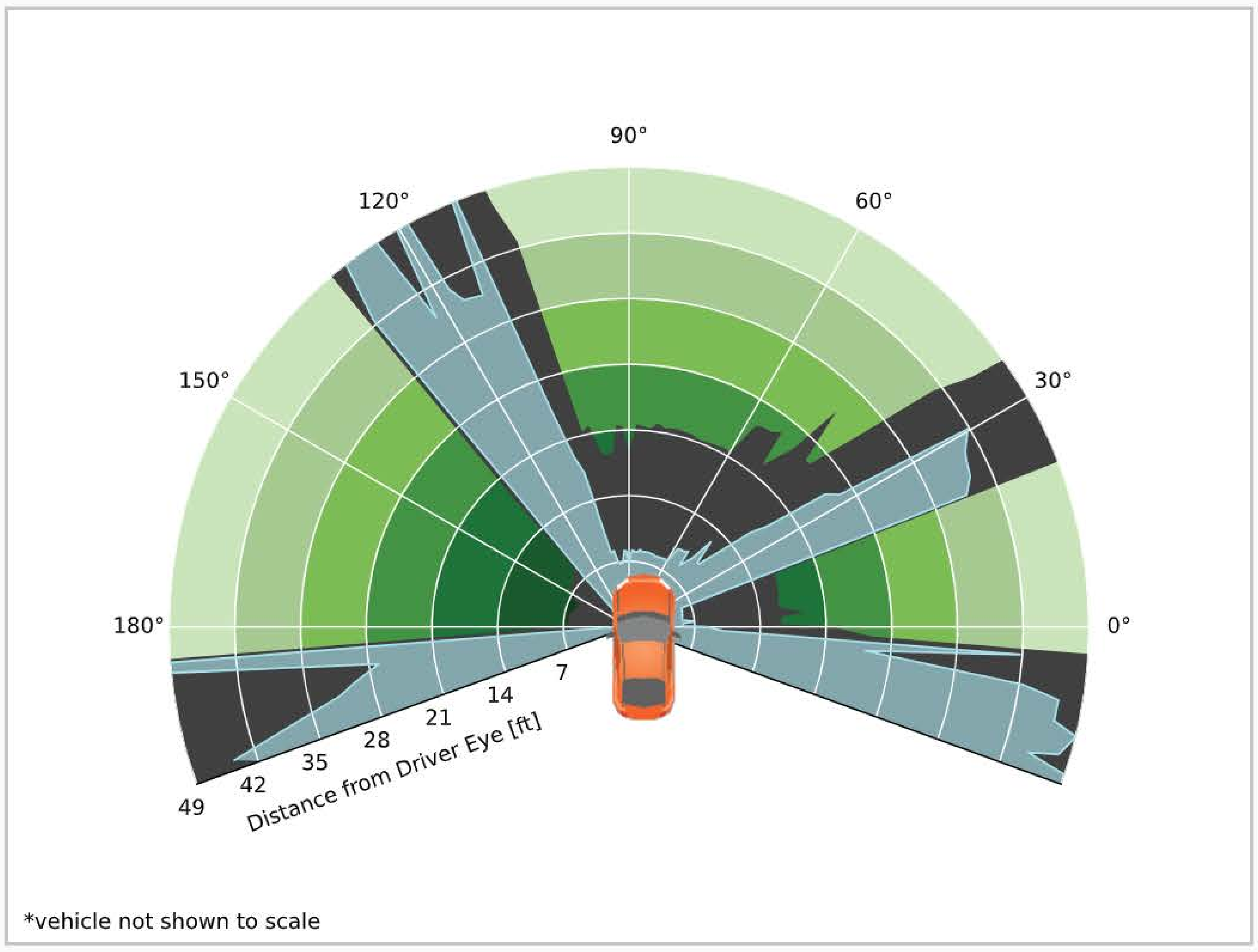
Visualization Results: elementary school child on bike

Overhead View

Birds-eye view of the vehicle and surrounding blindzones.

The closest forward-visible **elementary school child on bike** is **0 ft** in front of the vehicle.
There are **231 elementary school children on bikes** hidden in the blindzone.

- ground blindzone
- elementary school child on bike blindzone
- visible zone



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