

Digital Reconstruction - Supplementary Report

Tuesday, 4 October 2022

Version 1.01r

On behalf of the Sheku Bayoh Inquiry

**SHEKU
BAYOH
INQUIRY**

ABOUT US

Advanced Laser Imaging Ltd formed in late 2013 and specialise in the 3-Dimensional recording of objects and locations for the purposes of conducting accurate spatial analysis. They use a range of specialist survey equipment including Laser Scanners to rapidly survey a scene and produce a 1:1 virtual reconstruction that can then be incorporated with other information or evidence that exists for the incident.

The Technical Directors who have worked on this project have 8 years' experience working as Police Staff specialists for the London Metropolitan Police Service conducting reconstructions of Crime Scenes and Major Incidents. They are experts in the field of 3D Geomatics and have produced evidence for hundreds of cases within the UK Criminal Justice System. They have been fortunate to have worked on some of the highest profile cases in recent decades and they continue to provide specialist support to Police and Security related organisations.

Since forming Advanced Laser Imaging, the team have been commissioned by Defence teams as well as Prosecution/Police and carry out other court work such as Civil courts (insurance) and Appeals.

ACRONYMS / DEFINITIONS

3D	3 Dimensions
ARLS	Automatic Resource Location System
Csv	Comma separated values - A text file
Digital Twin	An accurate Virtual 1 to 1 recreation of a real world scene
Digital Zoom	By enlarging pixels in the centre of the photo and cropping out the rest, digital zoom gives the appearance of magnifying the subject, while also lessening resolution and image quality.
EDM	Electronic Distance Measurement- is a method of determining the length between two points using electromagnetic waves.
Effective Focal length	Simplifying a complex cluster of lenses into a single virtual lens, the Effective Focal length is the relative distance from the sensor surface to the centre of this imaginary lens.
Frame Rate	The number of frames stored per second in a video or animation
Laser Scan	A survey technique involving a 3D scanner that measures millions of points in a scene during capture.
OSGB	Ordnance Survey Great Britain.
Photogrammetry	Techniques to take measurement from photography
Pointcloud	The common output from a laserscanner, a pointcloud is where a Digital twin is made up of millions or billions of individual points.
Registration	A process of stitching together multiple 3D laser scan generated pointclouds into a single large, pointcloud.
RMS	Root Mean Square - is defined as the square root of the mean square of a set
RTK	Real Time Kinematics - Used to improve the accuracy of GPS measurement to centimetres.
SOCO	Scene of Crime Officer
UAV	Unmanned Aerial Vehicle

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1. SUMMARY

- 1.1. On 2nd August 2021, Advanced laser Imaging were contacted by The Sheku Bayoh Inquiry team regarding a possible reconstruction.
- 1.2. Advanced Laser Imaging engaged with the Inquiry and conducted work in digital and 3D Reconstruction. The work resulted in several external products being delivered to the Inquiry, these are:
 - Cloud based 3D Virtual model
 - Evidence Video Timeline
 - Combined Audio and Video Timeline
 - Scene Overview Video
 - Enhanced Snapchat Video
- 1.3. The production of all of this work is covered by a initial report (SBPI-00149)
- 1.4. This report covers the work carried on from the creation of these products and the workflows designed and used through the hearings.

2. INQUIRY SET UP AND USE FOR LIVE HEARINGS

2.1. EVIDENTIAL CONSIDERATIONS

- 2.1.1. 3D models are a powerful visual tool. When used incorrectly they could cause incorrect recall from those giving evidence. To reduce the effect this could have on witnesses, all witnesses will go through the same methodology when using the 3D system.
- 2.1.2. The process is aimed to reduce leading of witnesses, whilst also not limiting questions that can be asked of a witness by having information predefined in the scene.

2.2. PRACTICAL CONSIDERATIONS

- 2.2.1. When conducting real-time manipulation of 3D data, it is important to keep operations as simple as possible. Large pauses in the hearing would not only affect the timetable of the hearing, but also the flow and engagement of those giving evidence.
- 2.2.2. Therefore, operations for live assessment will be limited to moving people's positions and orientations within the 3D scene.

2.3. METHODOLOGY FOR LIVE ASSESSMENT

- 2.3.1. Placement of people in the 3D scene was to be carried out in two stages.
 - A. Initial placement on pre-rendered stills
 - B. Adjustments made in a live 3D View

2.3.2. INITIAL PLACEMENT ON PRE-RENDERED STILLS

- 2.3.2.1. Initially pre-rendered images of the scene without people positioned in it were used to place people as they gave their evidence. Vehicles were included as they were derived by photogrammetry from Ashley Wyse's Snapchat videos. Images were also created without vehicles in place in case these were more suitable.
- 2.3.2.2. Using the Inquiry's touchscreen system, witnesses were able to position themselves in a rendered image without any influence from the 3D model being manipulated or moved. Users were able to place either circles or arrows on the pre rendered images which are recorded as part of the hearing's live stream.

2.3.2.3. When asking questions about a person's location, a witness was asked for:

- Their location - which can be recorded on the screen
- Their orientation - in reference to people or objects in the scene
- Their pose - this can be verbal or it can be demonstrated.

2.3.2.4. Whilst this initial evidence was being collected, a recreation of people's position and orientation was being conducted in a separate room by an operator viewing the live feed. People were added either standing up or lying down, their heights added based on information supplied through evidence. People's heights were not verified or adjusted for wearing footwear.

2.3.2.5. There were two sets of images created for use by the Inquiry team in the initial stage of questioning. These were called 'Still Images' (SBPI-00127) and 'Still Images 02' (SBPI-00129). The second set were created as it became clear that further images were required of the full scene with vehicles positioned as per the snapchat timings.

2.3.3. ADJUSTMENTS MADE IN A LIVE 3D VIEW

2.3.3.1. During a short break in the hearing, these recreated views were reviewed with the Inquiry's legal team and final reconstructions were created for events that had been described.

2.3.3.2. Witnesses were then able to review and describe any alterations they wanted to make live in the 3D reconstruction. An operator was able to move the virtual camera and get better views of the areas they were describing. Allowing for more accurate placement by the witness.

2.3.3.3. Movements were limited to position and orientation.

2.3.3.4. As an option it was also possible to take a line of sight view from the witness in the scene to help a witness visualise the events they describe more clearly. The software determines the eye height automatically based on anthropometrics from the 'Metric Handbook: Planning and Design Data, Sixth Edition, 2018'.

2.3.3.5. The view taken from the eye height is for assisting the witnesses and Chair, it does not replicate human vision, but can assist in understanding obstructions to a person's view.

2.3.3.6. All views and reconstructions were stored on the cloud system so they could be reviewed later.

3. FORD TRANSIT VAN POSITION

- 3.1. During the course of PC Walker's Evidence, he was asked to comment on the position of the Ford Transit in the 3D Scene. He observed that the vehicle's rear passenger wheel should be in contact with the bus stop lines, which it was not. He further stated that, therefore, there was either an issue with the positioning of the vehicle model or position of the bus stop lines.
- 3.2. On reviewing this within the Evidence Timeline, PC Walker's observations were valid, the Ford Transit was further away from the northernmost kerb in the reconstructed views.
- 3.3. After talking to the Inquiry about this, further analysis was carried out to determine the cause of the error.

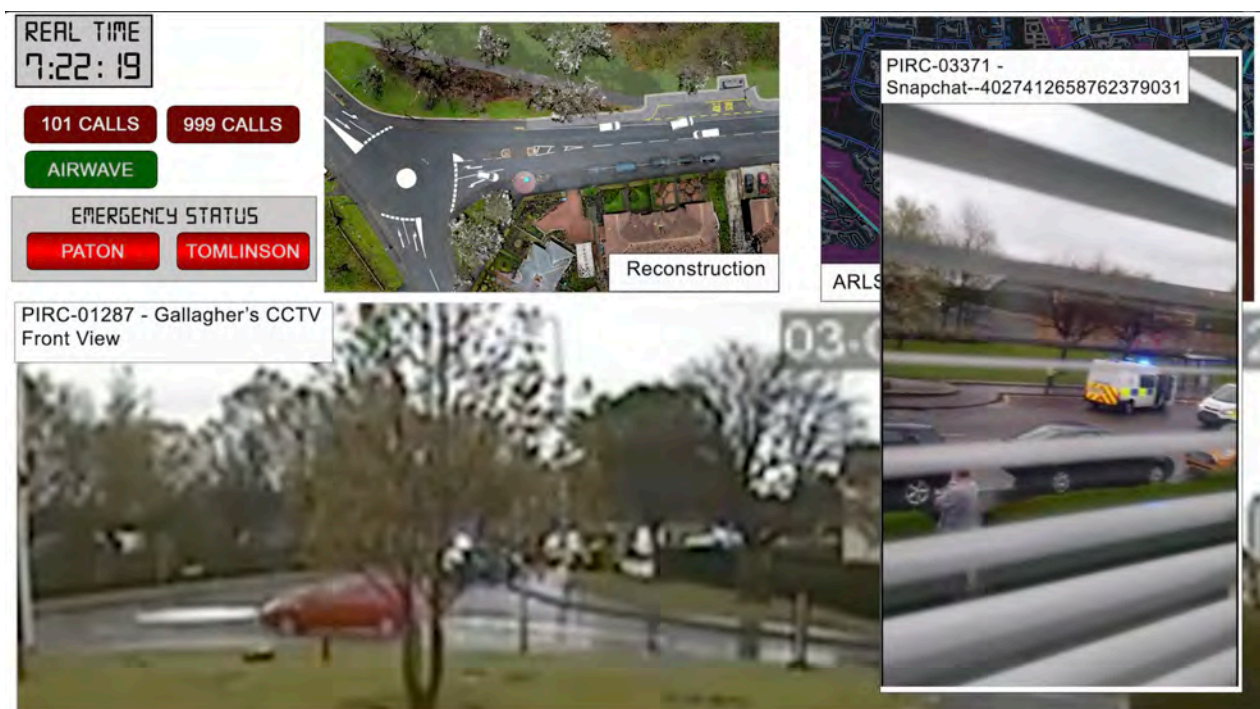


Figure 3.1 screenshot from Evidence Video Timeline.

3.4. Verification of line modelling

- 3.4.1. Firstly the road markings were checked by comparing the markings captured in the laser scan data from 2015 (SBPI-00004) with the 3D model generated.

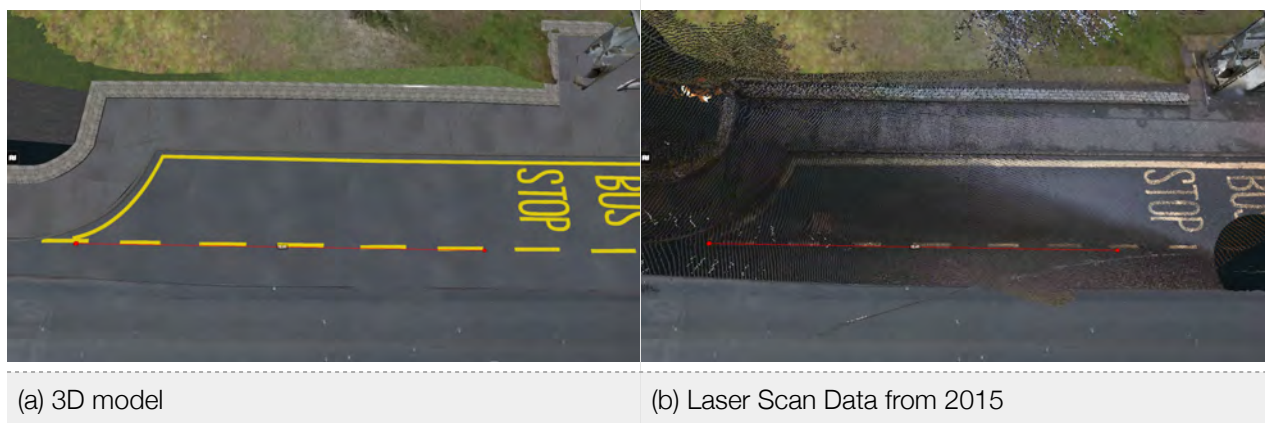


Figure 3.2 Comparison of Laserscan and Model

3.4.2. The line marking is accurate to within tolerance of the modelling, and this could be ruled out as the reason for the error, therefore, it was the vehicle location that was incorrect.

3.5. Verification of Photogrammetry Vehicle Positioning

3.5.1. As the vehicle position was inaccurate, the linework generated from the photogrammetry was tested alongside the model. This was carried out on PIRC-03371.

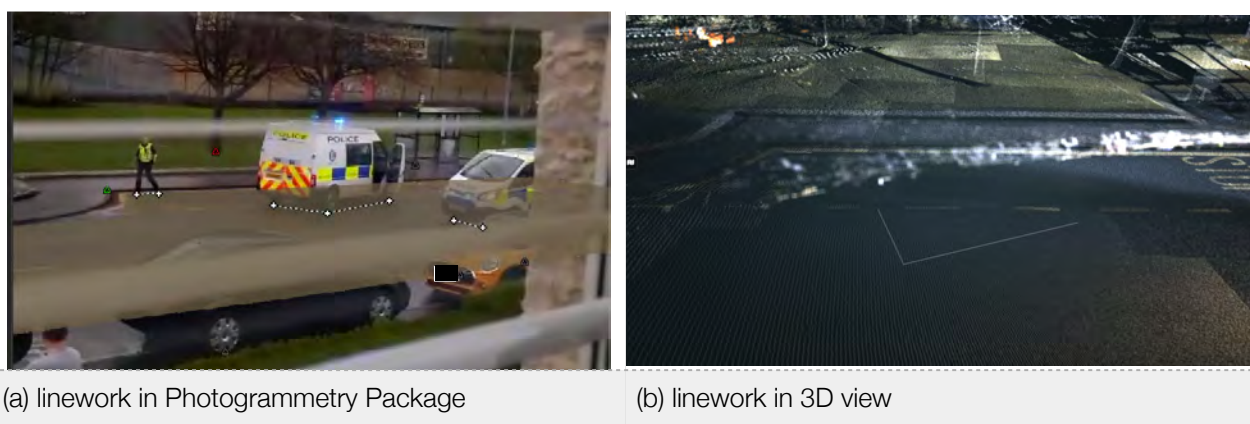


Figure 3.3 Linework drawn from Photogrammetry

3.5.2. In both the Photogrammetry and the 3D model, the linework appears to reflect the correct position, with the linework matching the observation. Therefore, the photogrammetry was not the cause of the issue.

3.6. Verification of Vehicle Positioning

3.6.1. Lastly, the model placement was checked.

- 3.6.2. A representative Ford Transit Van model had initially been placed in position within the scene based on the analysis. The figure below shows that this was correctly positioned.



Figure 3.4 Positioning of Ford Transit, initial model in correct location

- 3.6.3. After the next chronological snapchat footage had been assessed (PIRC-03370), it was clear that the vehicle type in the CCTV was shorter in length than the 3D Model used. It is usual that vans are manufactured to varying configurations, including different lengths and heights. The effect of varying length was most prominent in PIRC-03370 where the Ford Transit is side on and nearer to the camera.
- 3.6.4. When the corrected model was placed back into the analysis from PIRC-03371 the error has occurred and its position is now incorrect as shown in the figure below.



Figure 3.5 Repositioning of Ford Transit in incorrect position

- 3.6.5. This is a result of human error introduced post the model adjustment. Because the error is limited to this one vehicle and the final stage of the process, correcting it is simply a process of replacing the updated model back to the photogrammetry linework. This is shown in the image below.

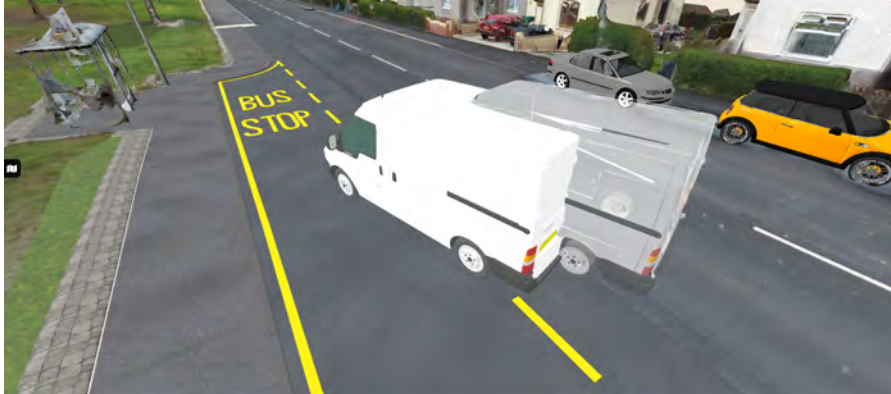


Figure 3.6 Transparent model shows incorrect position, opaque model is in the corrected position

3.7. Moving Forward

- 3.7.1. PC Walker's evidence was almost concluded by the time the error had been found, and a full quality assurance of this part of the process was required before introducing any changes to products.
- 3.7.2. PC Walker therefore concluded his evidence with the Ford Transit in the incorrect position. It is a matter for the Chair whether he wishes to hear further evidence from PC Walker in light of the position having been corrected.
- 3.7.3. Although a quantitative adjustment is not possible for PC Walker's evidence, a qualitative statement will be attached to all images relating to PC Walker where the Ford Transit position is incorrect.
- 3.7.4. Due to the time to render, correction of the 3D reconstruction tile in the top centre of the screen of the Evidence Video Timeline was not possible for the live hearings. However, adjustment to the still Image brochures (SBPI-00127 and SBPI-00129) and the cloud 3D model was possible, so all other witnesses were able to position themselves and others against the corrected vehicle position.

4. OUTPUT FROM INQUIRY LIVE SESSIONS

4.1. The output for each witness is shown below:

- Appendix A - PC Walker
- Appendix B - PC Short
- Appendix C - PC Tomlinson
- Appendix D - Mr K. Nelson
- Appendix E - PC Paton

4.2. PC Paton has only carried out the first phase of the process and not refined his positions. This should be considered when viewing his reconstructions.

5. OVERVIEW OF PRODUCTS

5.1. The figure below outlines the work conducted by Advanced Laser Imaging.

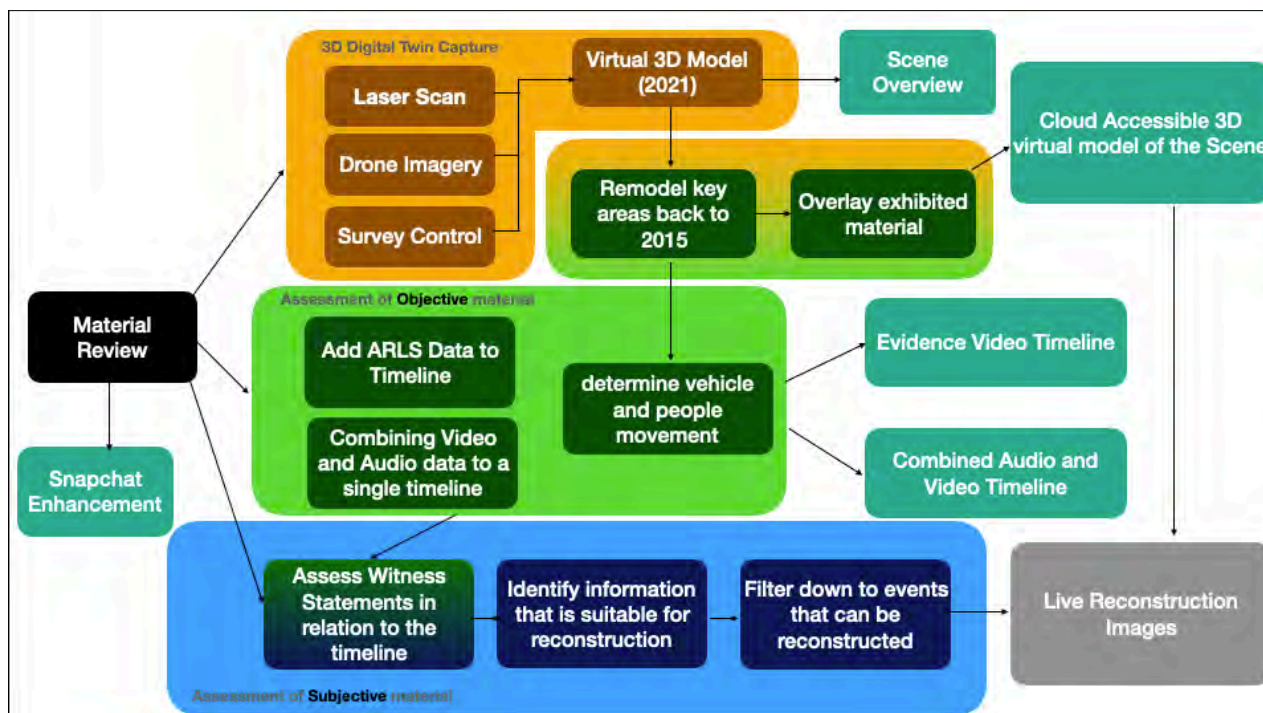
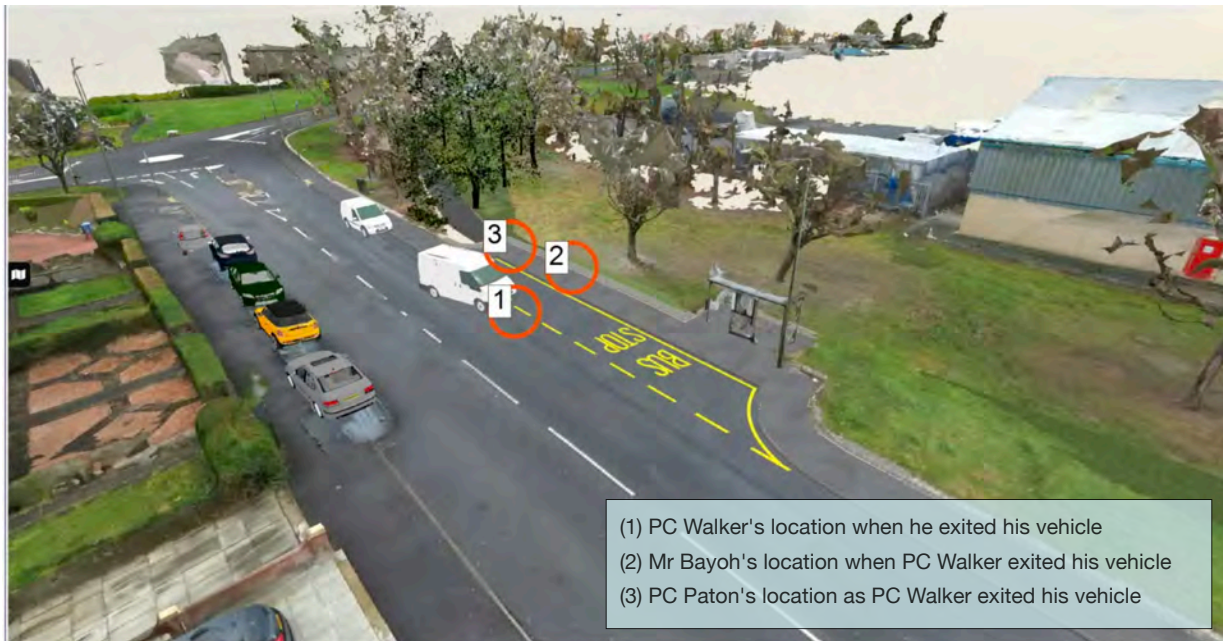


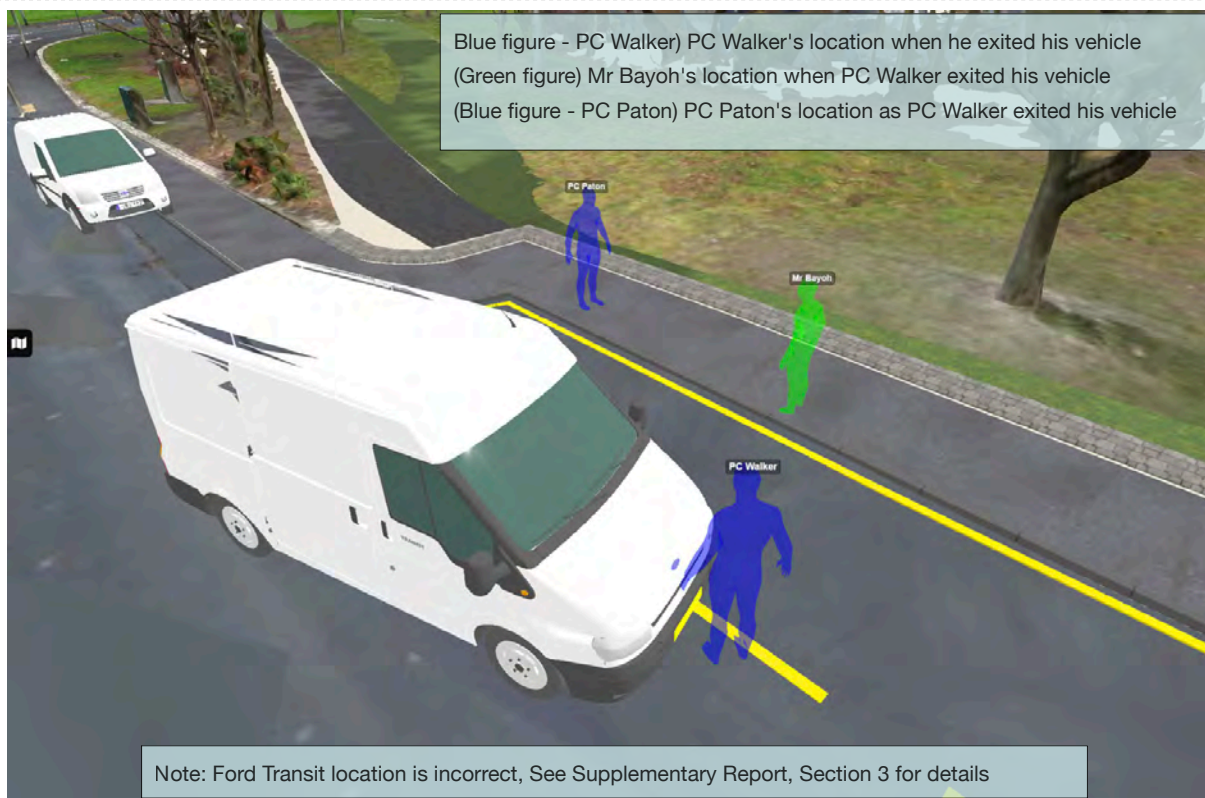
Figure 5.1 Workflow conducted by ALI

5.2. Over the course of the project some amendments were needed from the original proposal. Advanced Laser Imaging delivered more products to the Inquiry than initially proposed. These products were drawn out in meetings where the Inquiry team saw more value in the work and ways it could benefit the hearings.

APPENDIX A - PC WALKER'S EVIDENCE

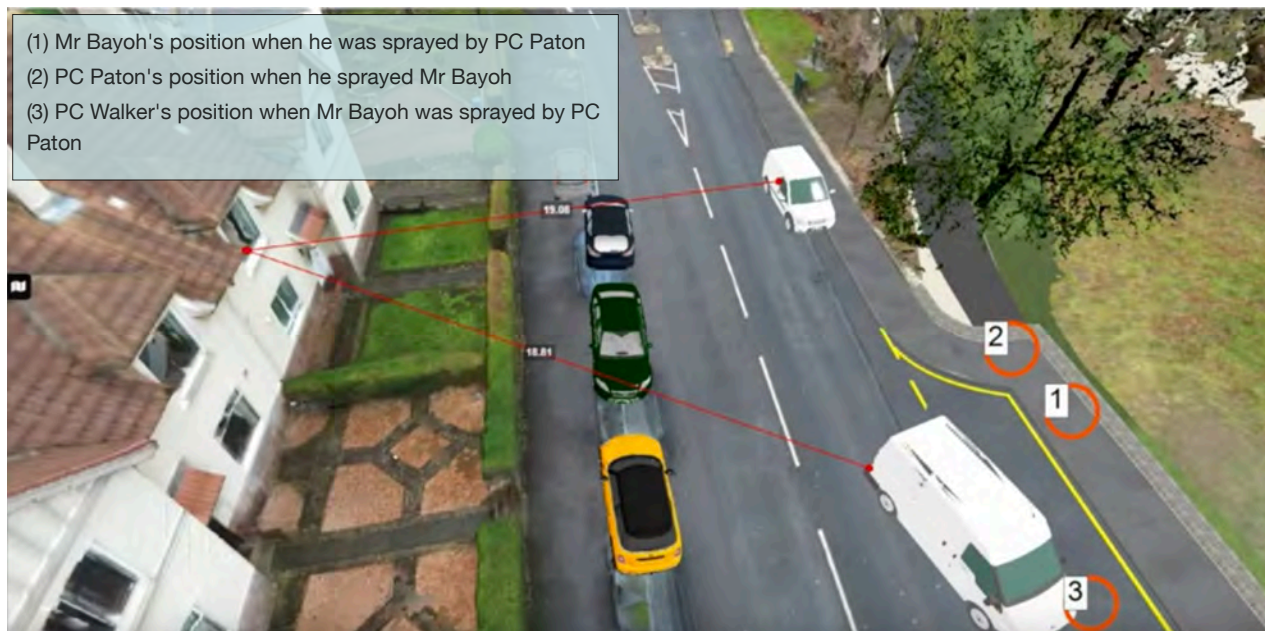


(a) Initial locations identified, PC Craig Walker (pm) - 19/05/2022. From 00:54:35.

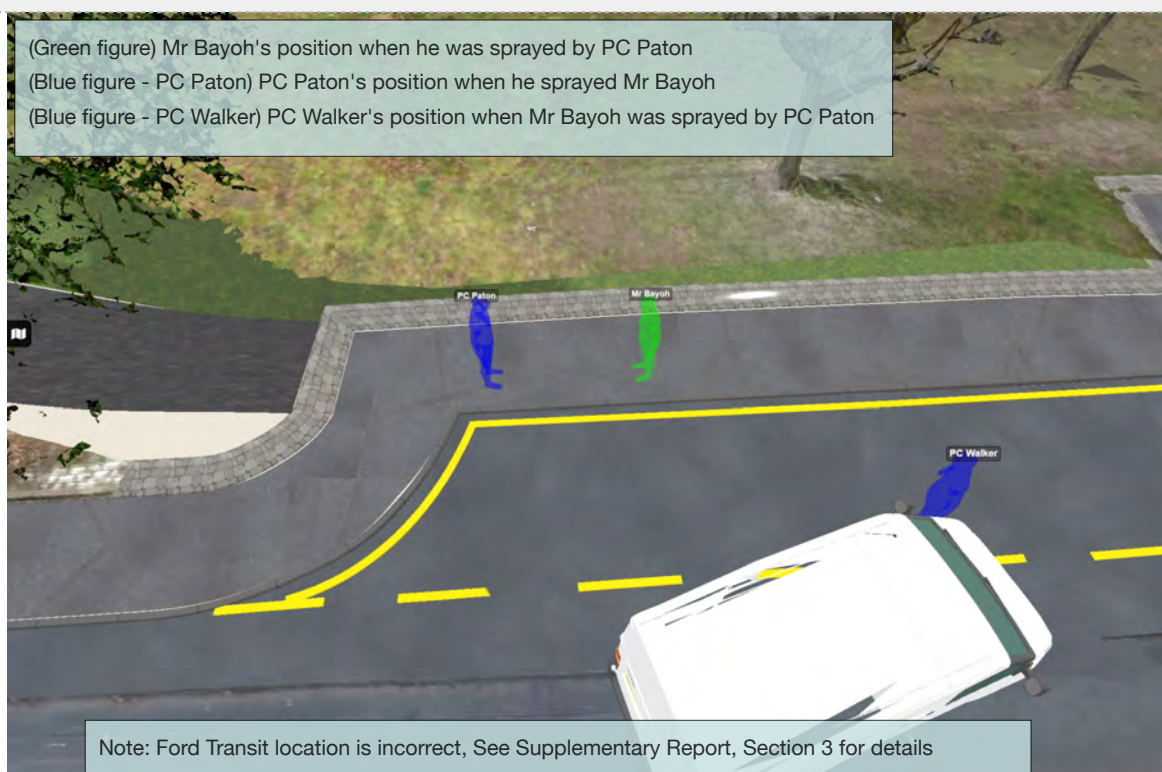


(b) Refined positions, PC Walker (am) - 20/05/2022. From 02:01:30.

Figure A.1: PC Walker describing the locations of people as he exits the vehicle

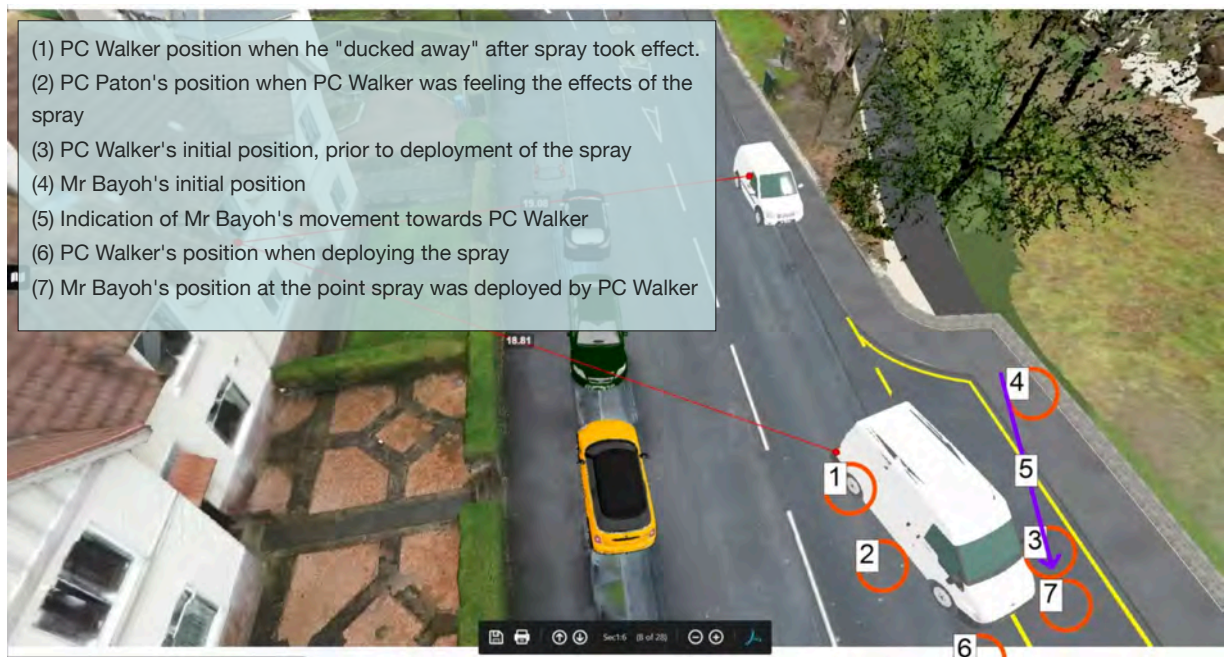


(a) Initial locations identified, PC Craig Walker (pm) - 19/05/2022. From 01:04:10.

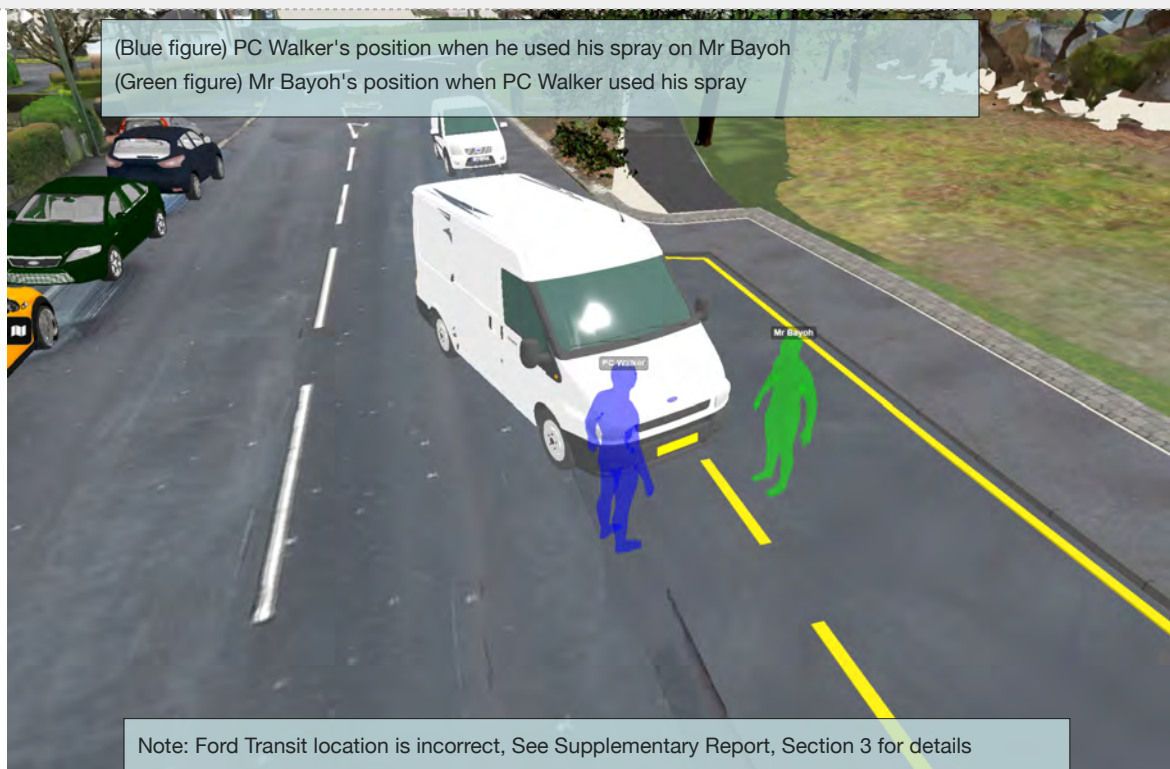


(b) Refined positions, PC Craig Walker (am) - 20/05/2022. From 02:04:50

Figure A.2: PC Walker describing locations of people as PC Paton deploys CS Spray

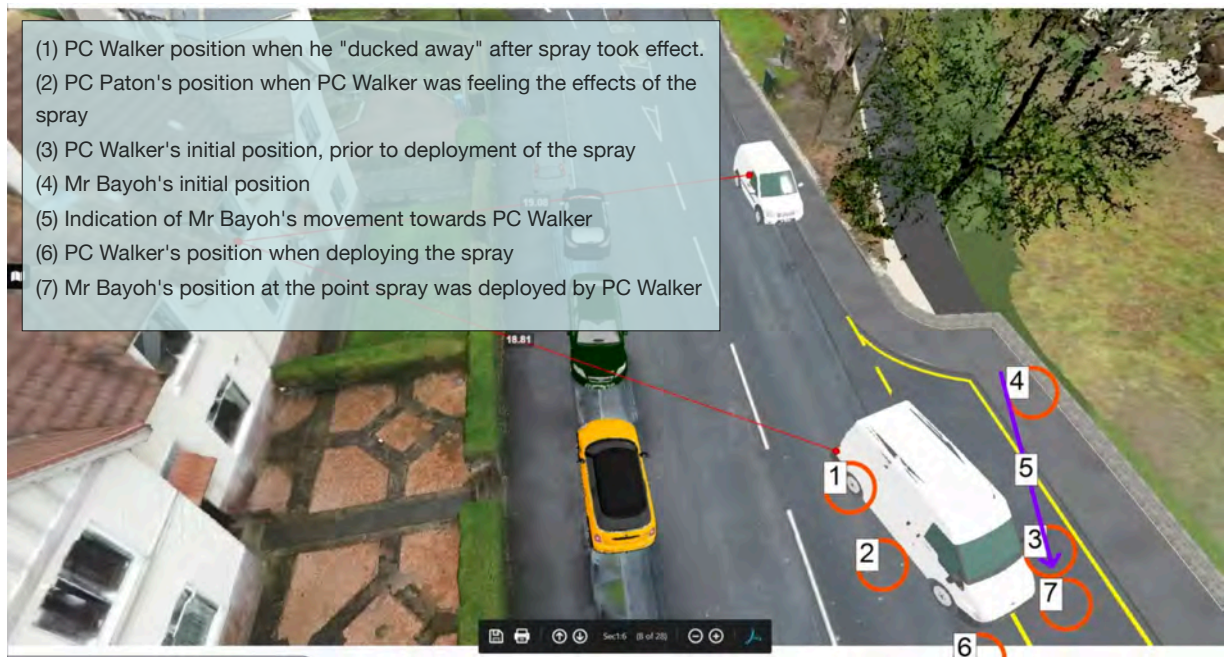


(a) Initial locations identified, PC Walker (pm) - 19/05/2022. From 01:50:25.

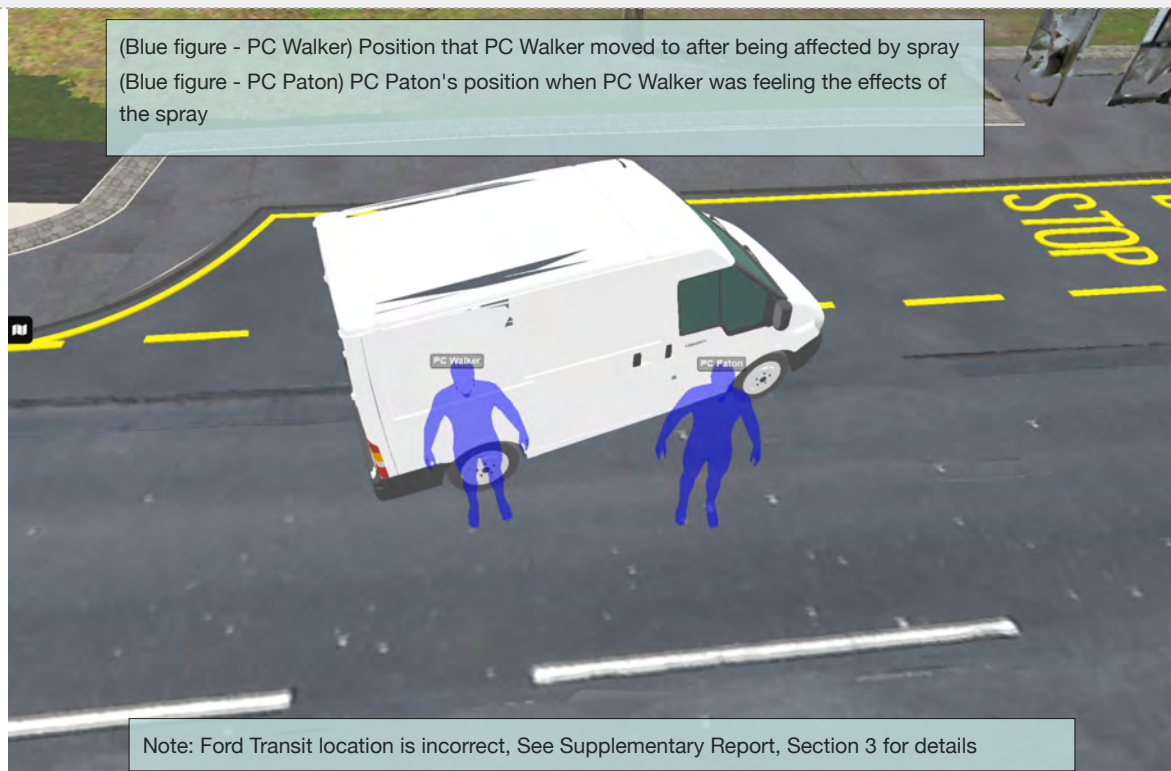


(b) Refined positions, PC Walker (am) - 20/05/2022. From 02:07:10.

Figure A.3: PC Walker describing locations of people as he deploys Pava Spray



(a) Initial locations identified, PC Walker (pm) - 19/05/2022. From 01:50:25.

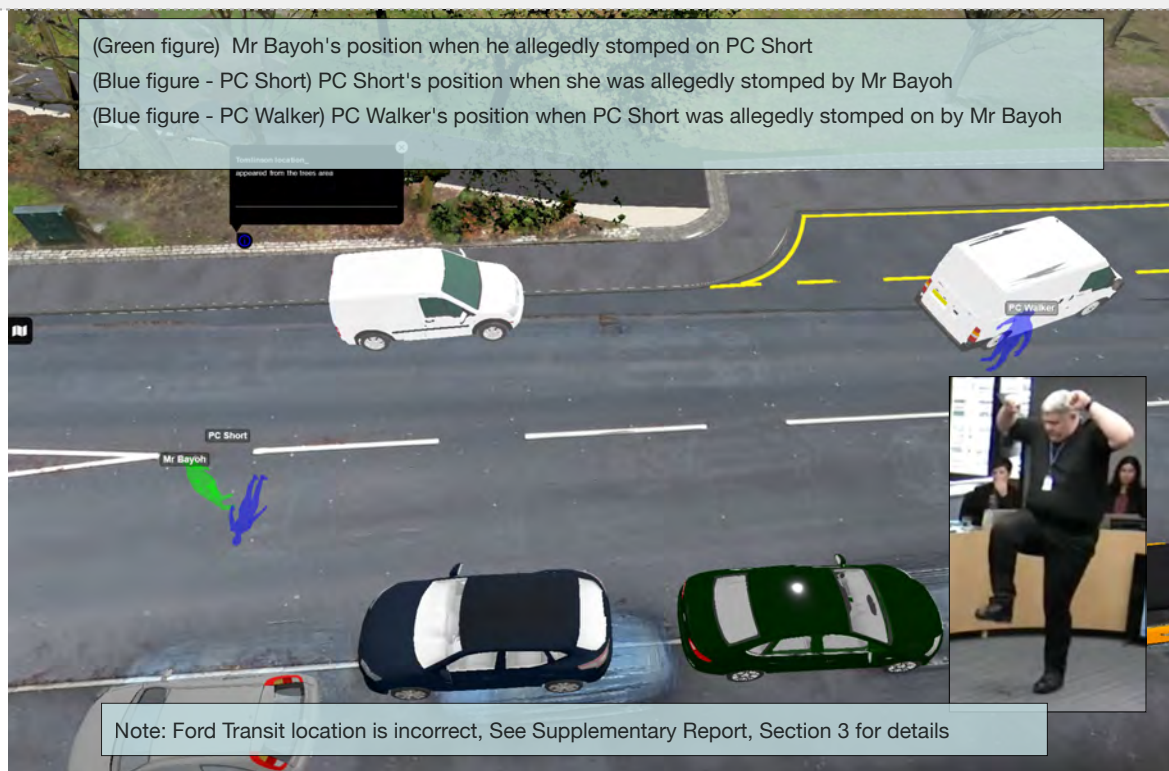


(b) Refined positions, PC Walker (am) - 20/05/2022. From 02:08:50

Figure A.4: PC Walker describing locations of people post Pava deployment



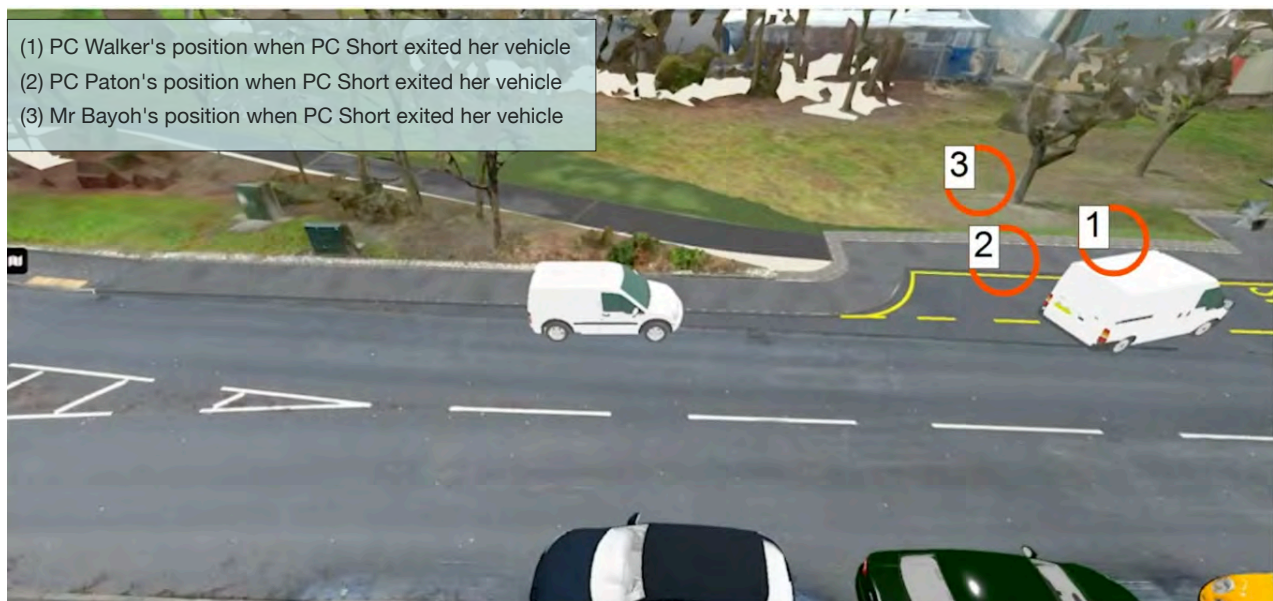
(a) Initial locations identified, PC Walker (am) - 20/05/2022. From 00:26:22.



(b) Refined positions, PC Walker (am) - 20/05/2022. From 02:13:30 - Inset PC Walker demonstrating the alleged stomp, PC Walker (am) - 20/05/2022. From 00:31:00.

Figure A.5: PC Walker describing location where PC Short fell and was allegedly stomped

APPENDIX B - PC SHORT'S EVIDENCE

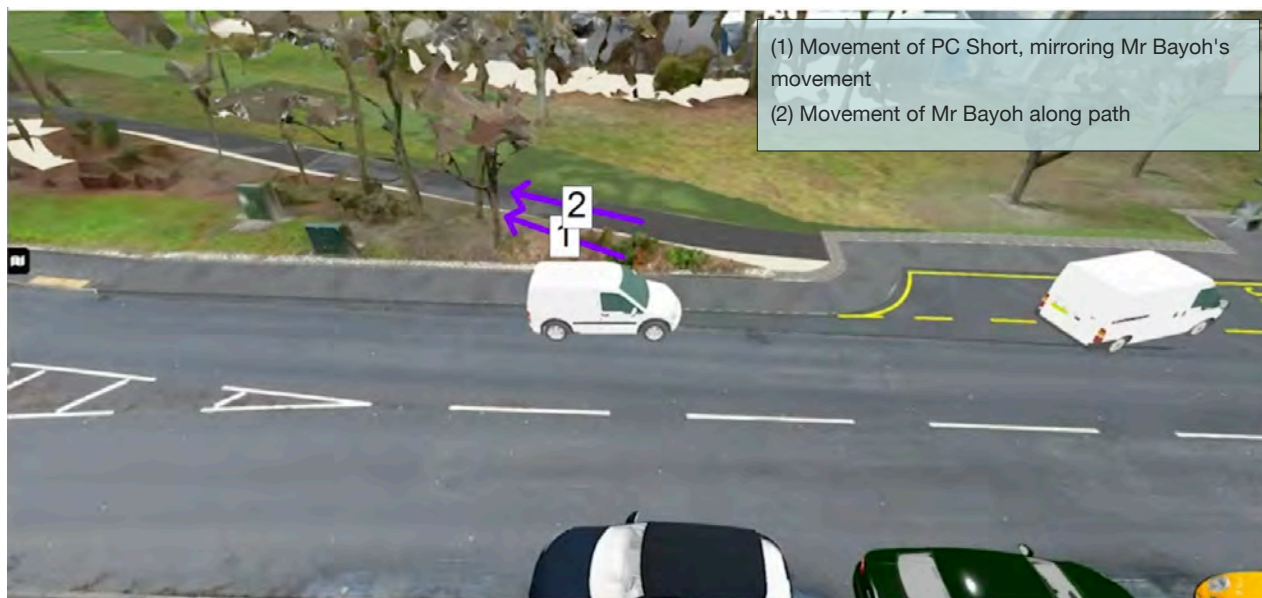


(a) Initial locations identified, Nicole Short (am) - 24/05/2022. From 01:14:30.



(b) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:29:40 - Inset, Line of sight view from PC Short, Nicole Short (pm) - 24/05/2022. From 00:32:25

Figure B.1 PC Short describes locations of people as she exits her vehicle

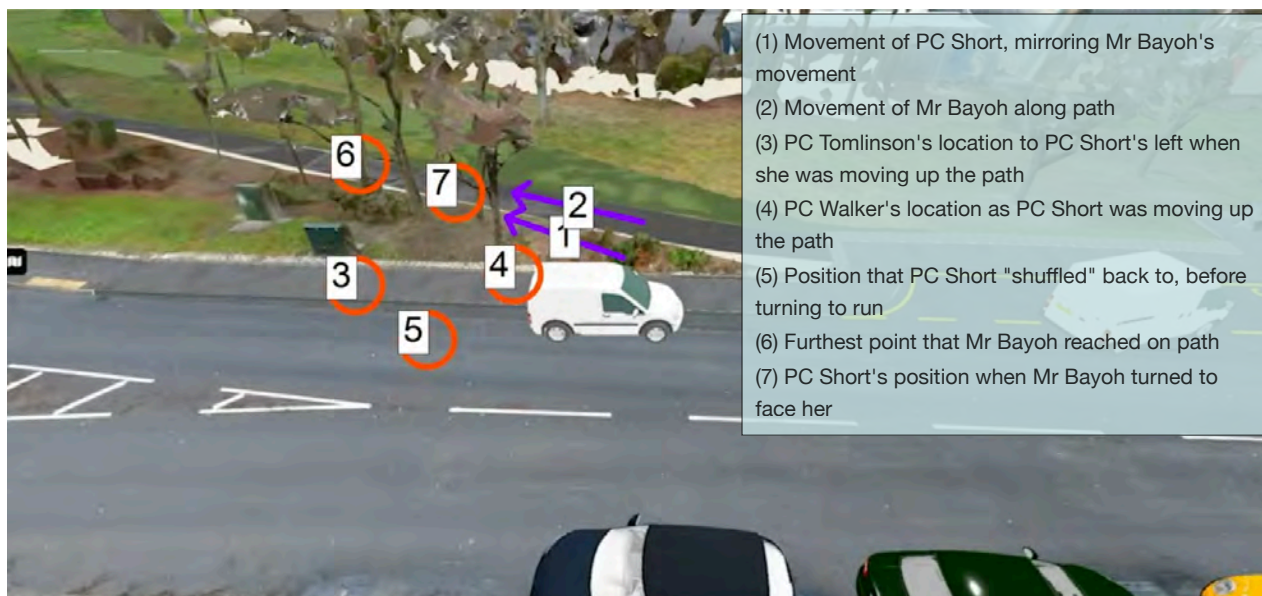


(a) Initial locations identified, Nicole Short (am) - 24/05/2022. From 02:04:50.



(b) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:33:20.

Figure B.2 PC Short describes movement of Mr Bayoh along path

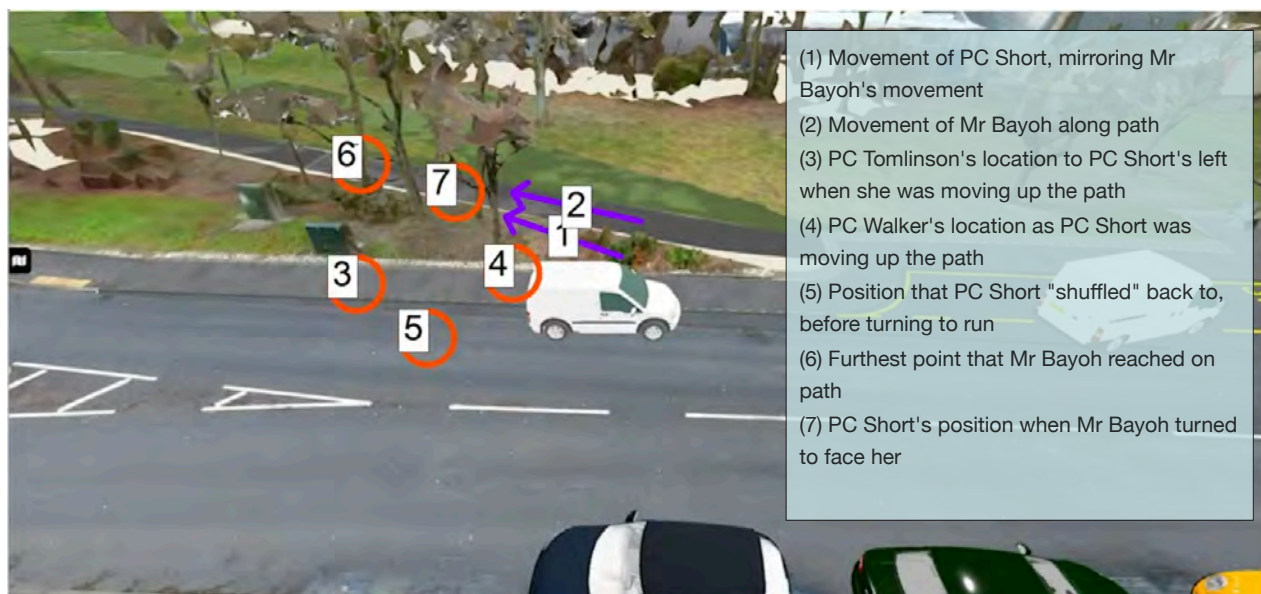


(a) Initial locations identified, Nicole Short (am) - 24/05/2022. From 02:06:30.



(b) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:33:20.

Figure B.3 PC Short describes locations of people as Mr Bayoh reaches furthest point along path.



(a) Initial locations identified, Nicole Short (am) - 24/05/2022. From 02:06:30.

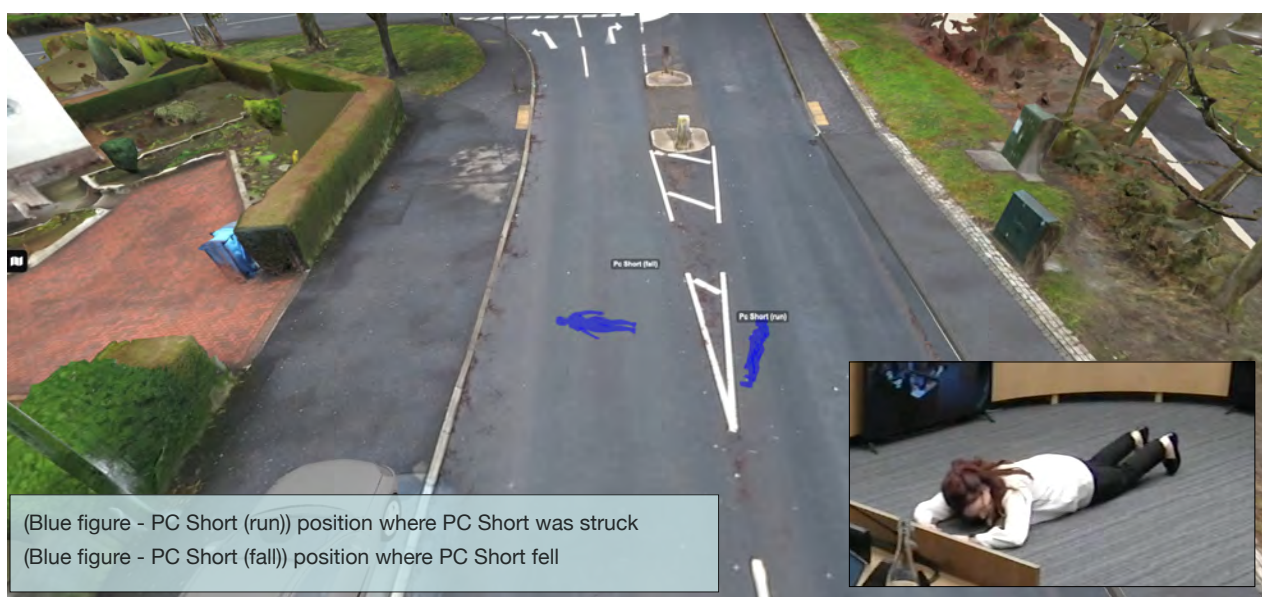


(b) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:36:30.

Figure B.4: PC Short describes her position on the road before turning to run, with Mr Bayoh 'closing the gap'



(a) Initial locations identified, Nicole Short (am) - 24/05/2022. From 02:26:00.

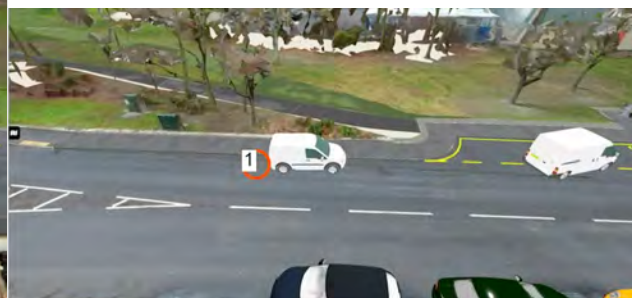


(b) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:37:50 Inset- PC Short demonstrating her pose on the ground, Nicole Short (am) - 24/05/2022. From 02:45:10.

Figure B.5: PC Short describes where she ran to and where she landed in the road



(1) Position of Mr Bayoh where he was being restrained by PCs Tomlinson, Paton and Walker.



(1) PC Short's position when she moved away to the Fishvan after getting off the ground.

(a) Initial locations identified - where Mr Bayoh was being restrained, Nicole Short (am) - 24/05/2022. From 03:16:25 and again from 03:22:20

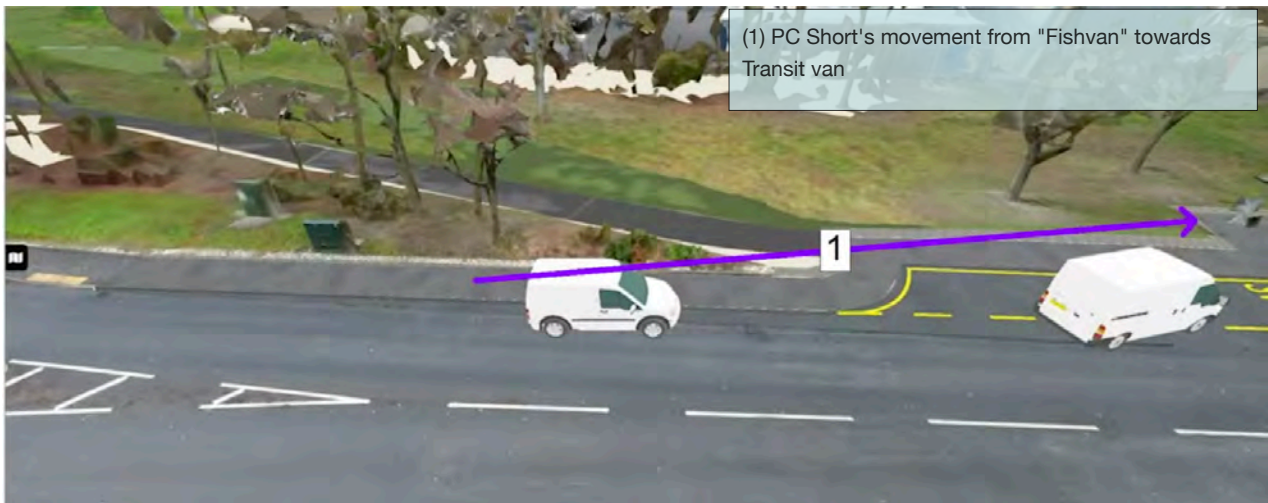
(b) Initial locations identified - where PC Short moved to after getting up from the ground, Nicole Short (am) - 24/05/2022. From 03:15:10.



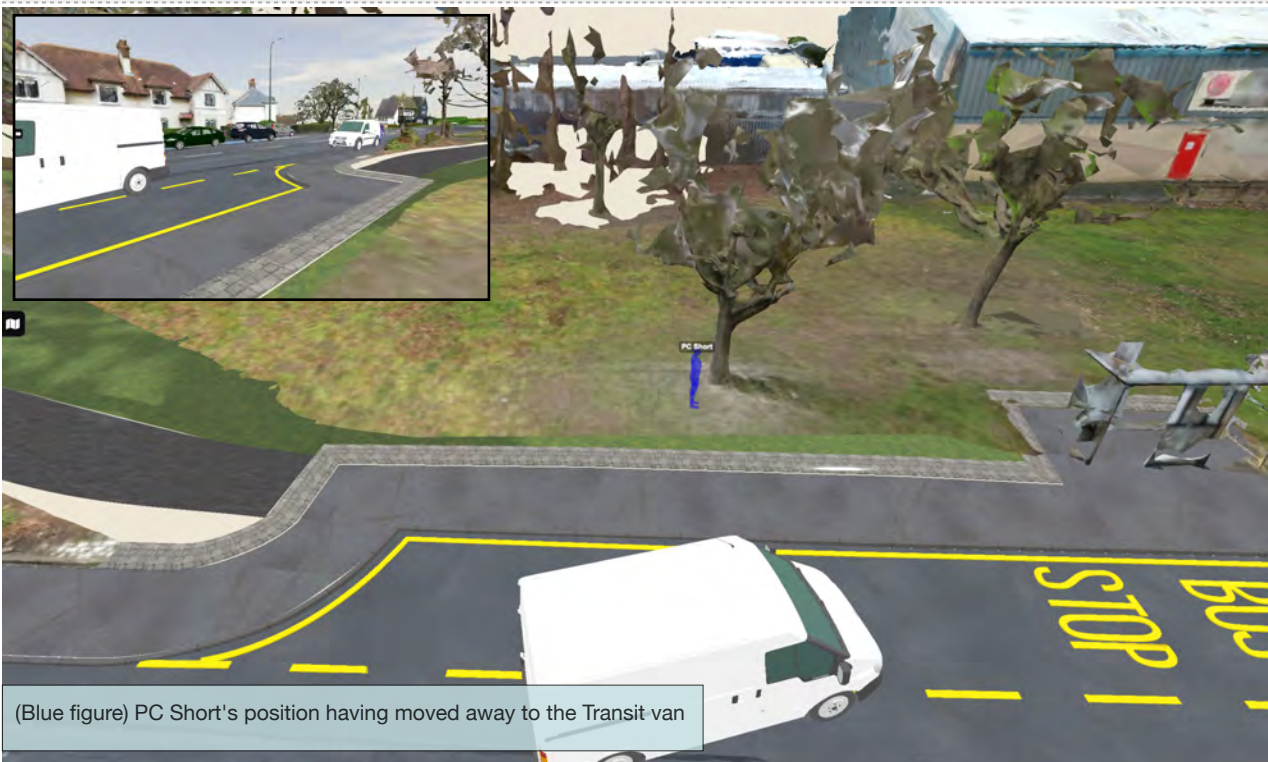
(Green figure) Mr Bayoh's position when he was brought to the ground
(Blue figure) PC Short's position having got up from the ground and moved to Fishvan

(c) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:41:30.

Figure B.6: PC Short describes the area of restraint and her immediate position after getting up from the ground.



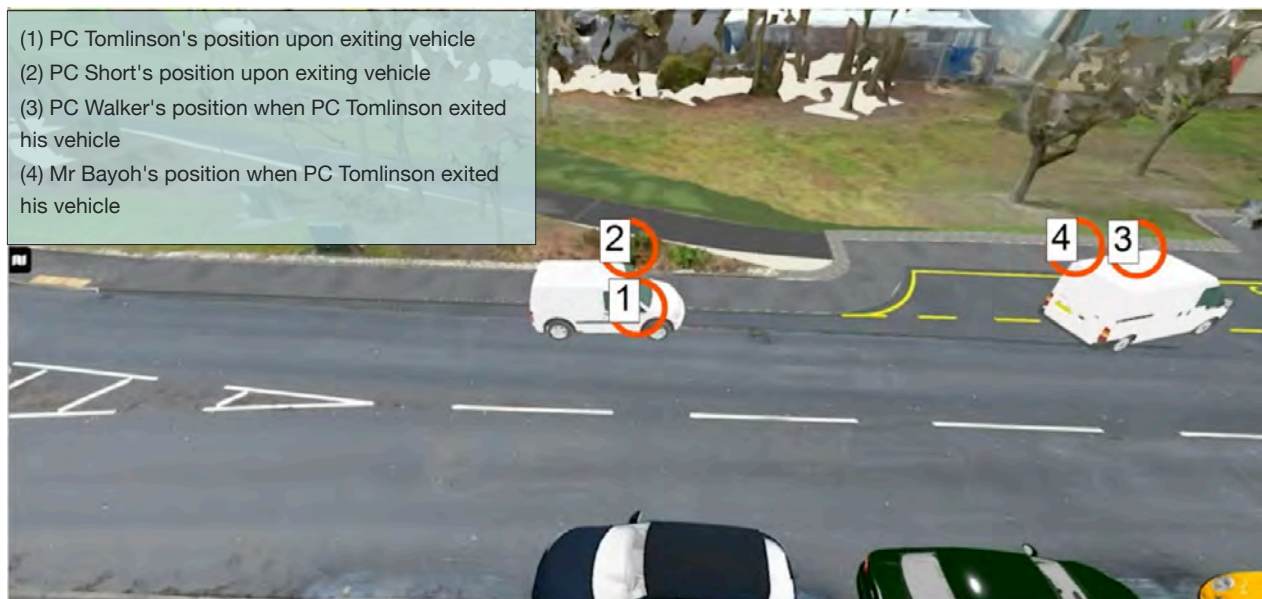
(a) Initial locations identified, Nicole Short (am) - 24/05/2022. From 03:24:20.



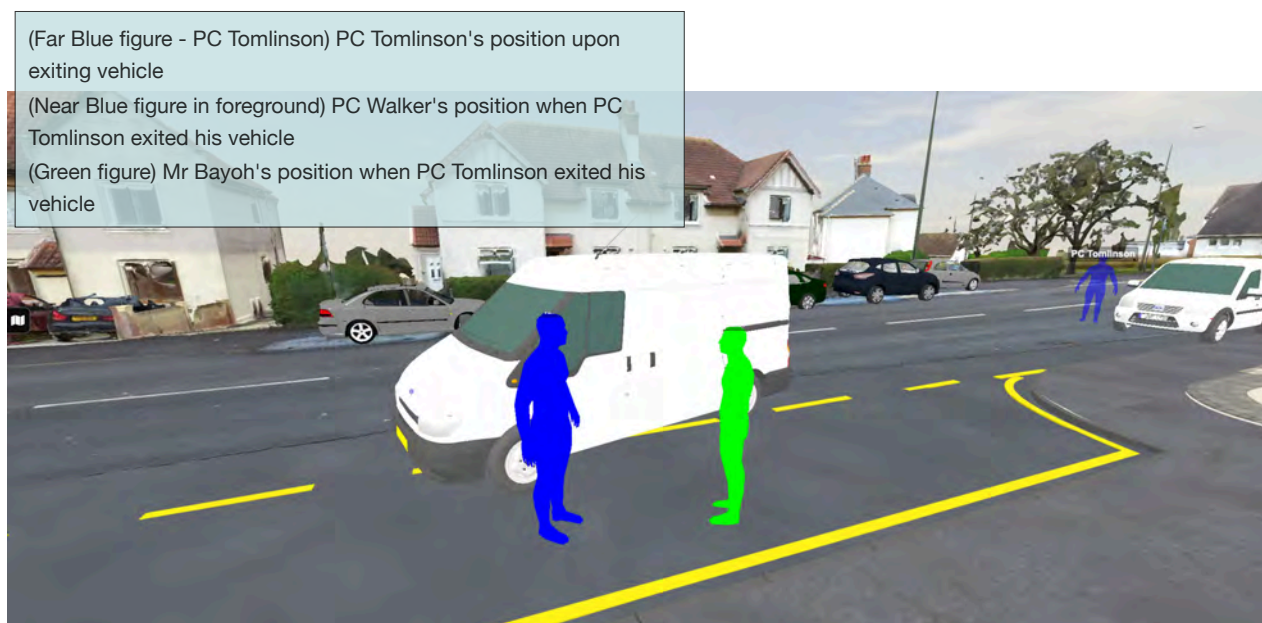
(b) Refined positions, Nicole Short (pm) - 24/05/2022. From 00:43:00 - Inset - line of sight. Nicole Short (pm) - 24/05/2022. From 00:44:10.

Figure B.7: PC Short describes moving away from the 'Fishvan' (Ford Connect)

APPENDIX C - PC TOMLINSON'S EVIDENCE

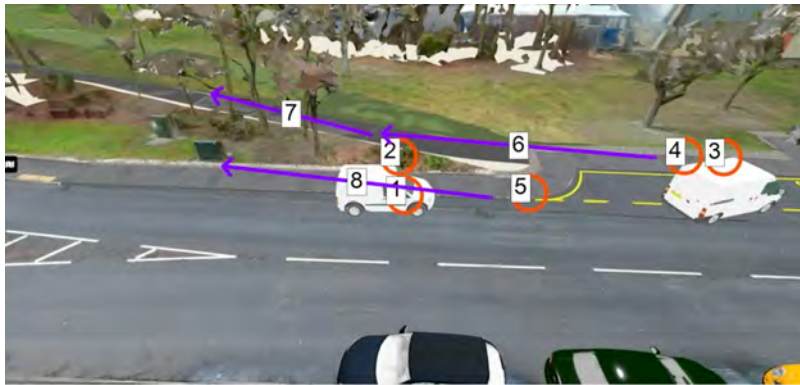


(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. From 01:42.10.



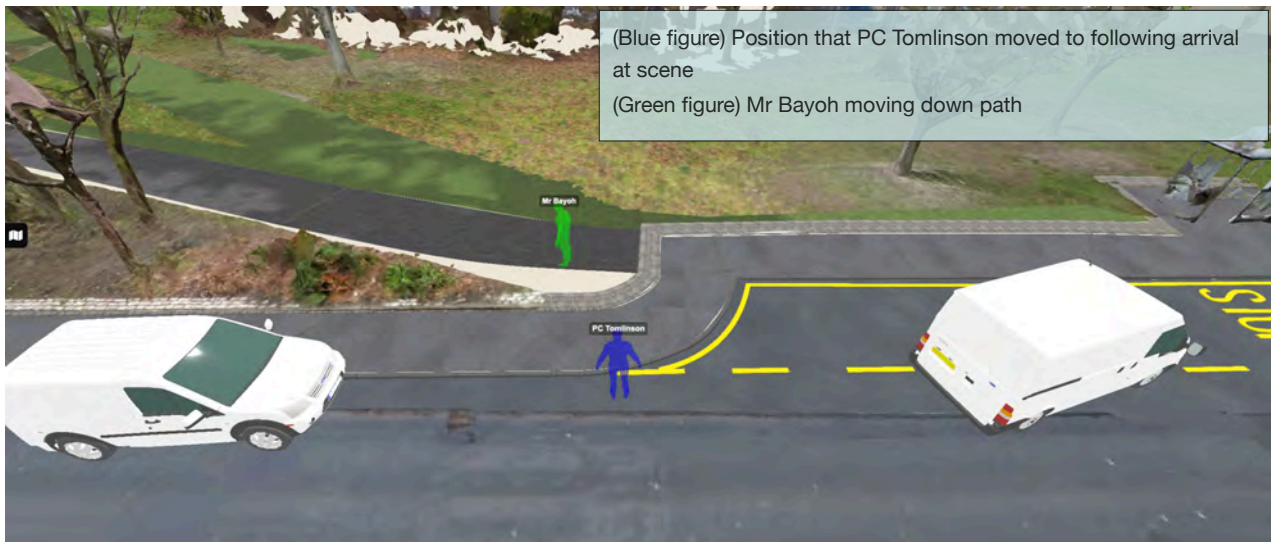
(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 02:34:50.

Figure C.1: PC Tomlinson describes locations of people after exiting his vehicle



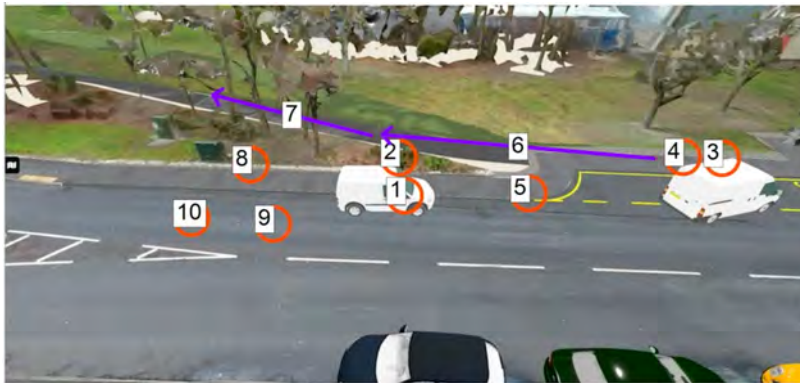
- (1) PC Tomlinson's position upon exiting vehicle
- (2) PC Short's position upon exiting vehicle
- (3) PC Walker's position when PC Tomlinson exited his vehicle
- (4) Mr Bayoh's position when PC Tomlinson exited his vehicle
- (5) Position PC Tomlinson moved to following arrival at scene
- (6) Mr Bayoh's movement away from PC Walker
- (7) Mr Bayoh's continued movement down the path
- (8) PC Tomlinson's movement mirroring Mr Bayoh walking down the path

(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. Numbers 1 - 4 from 01:42:10. Numbers 5 and 6 from 01:47:15. Numbers 7 - 8 from 01:54:45.



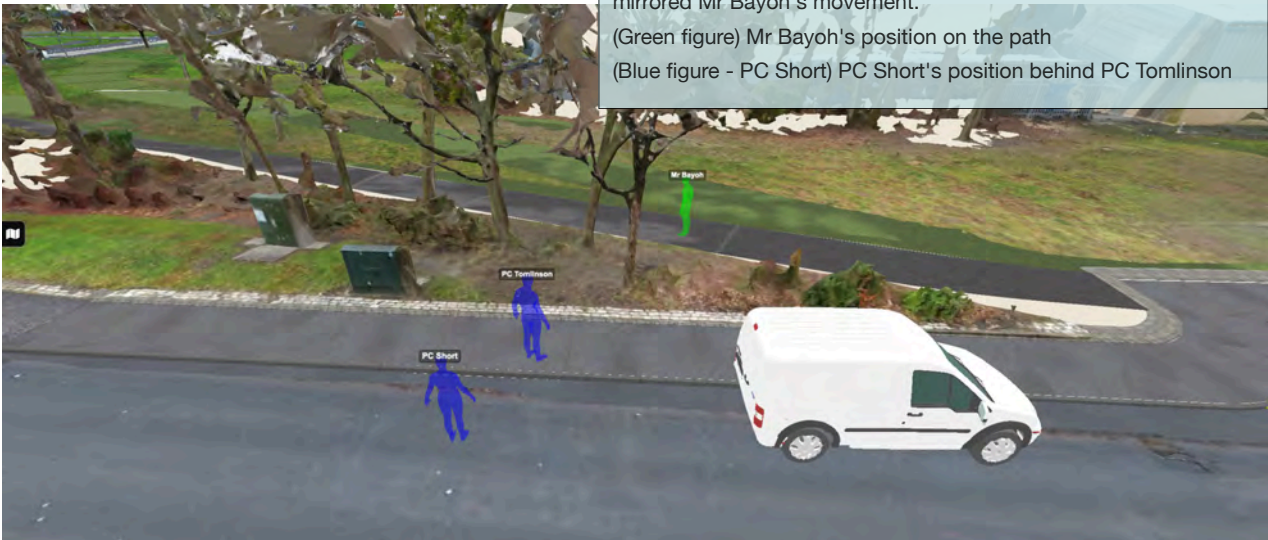
(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 02:40:00.

Figure C.2: PC Tomlinson describes Mr Bayoh walking up the path



- (1) PC Tomlinson's position upon exiting vehicle
- (2) PC Short's position upon exiting vehicle
- (3) PC Walker's position when PC Tomlinson exited his vehicle
- (4) Mr Bayoh's position when PC Tomlinson exited his vehicle
- (5) Position PC Tomlinson moved to following arrival at scene
- (6) Mr Bayoh's movement away from PC Walker
- (7) Mr Bayoh's continued movement down the path
- (8) PC Tomlinson's position after mirroring Mr Bayoh's movement
- (9) First option for PC Short's position when PC Tomlinson was at position (8). PC Short was behind PC Tomlinson
- (10) Second option for PC Short's position when PC Tomlinson was at position (8). PC Short was behind PC Tomlinson

(a) Initial locations identified PC Tomlinson (pm) - 25/05/2022. Numbers 1 - 4 from 01:42:10. Numbers 5 and 6 from 01:47:15. Numbers 7 - 8 from 01:54:45.

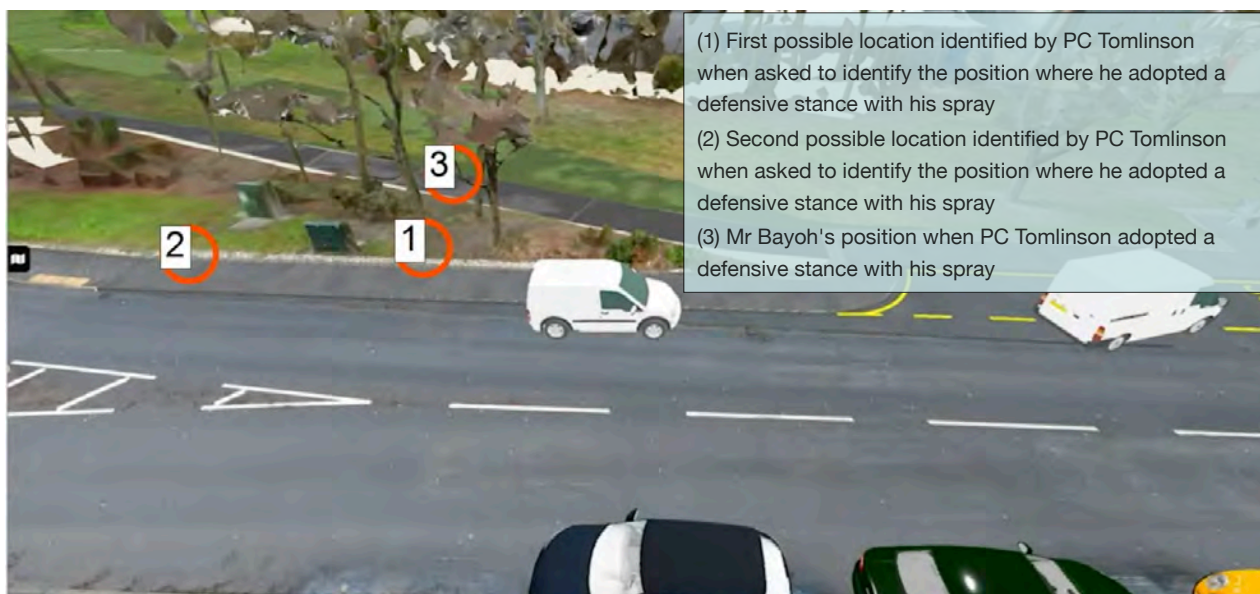


- (Blue figure - PC Tomlinson) PC Tomlinson's position having mirrored Mr Bayoh's movement.
- (Green figure) Mr Bayoh's position on the path
- (Blue figure - PC Short) PC Short's position behind PC Tomlinson

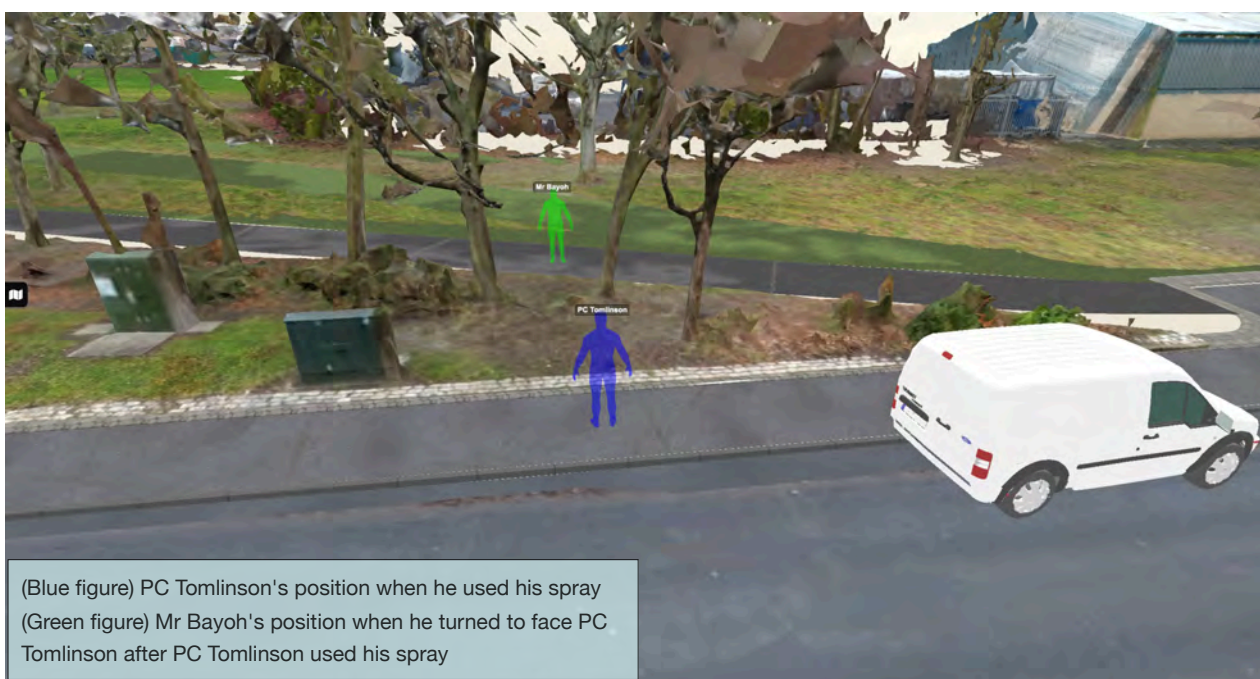
Note: PC Tomlinson knows PC Short is behind him, but not sure where.

(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 02:44:55.

Figure C.3: PC Tomlinson describes how far Mr Bayoh walked along the path and spraying him with Pava

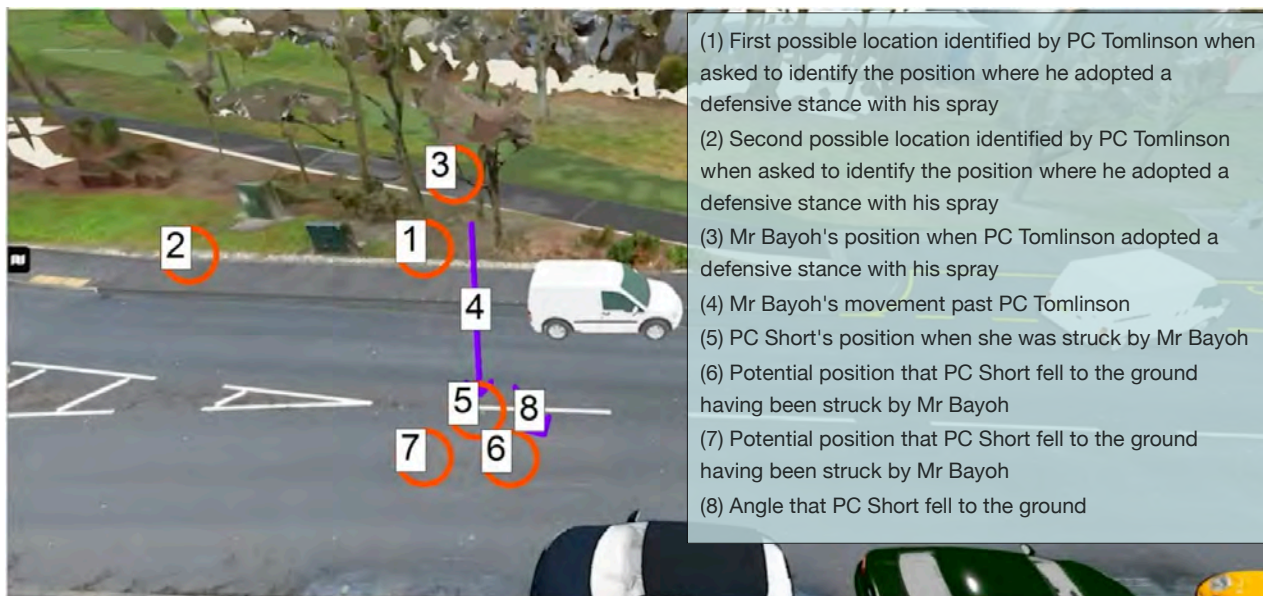


(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. From 02:29:15.

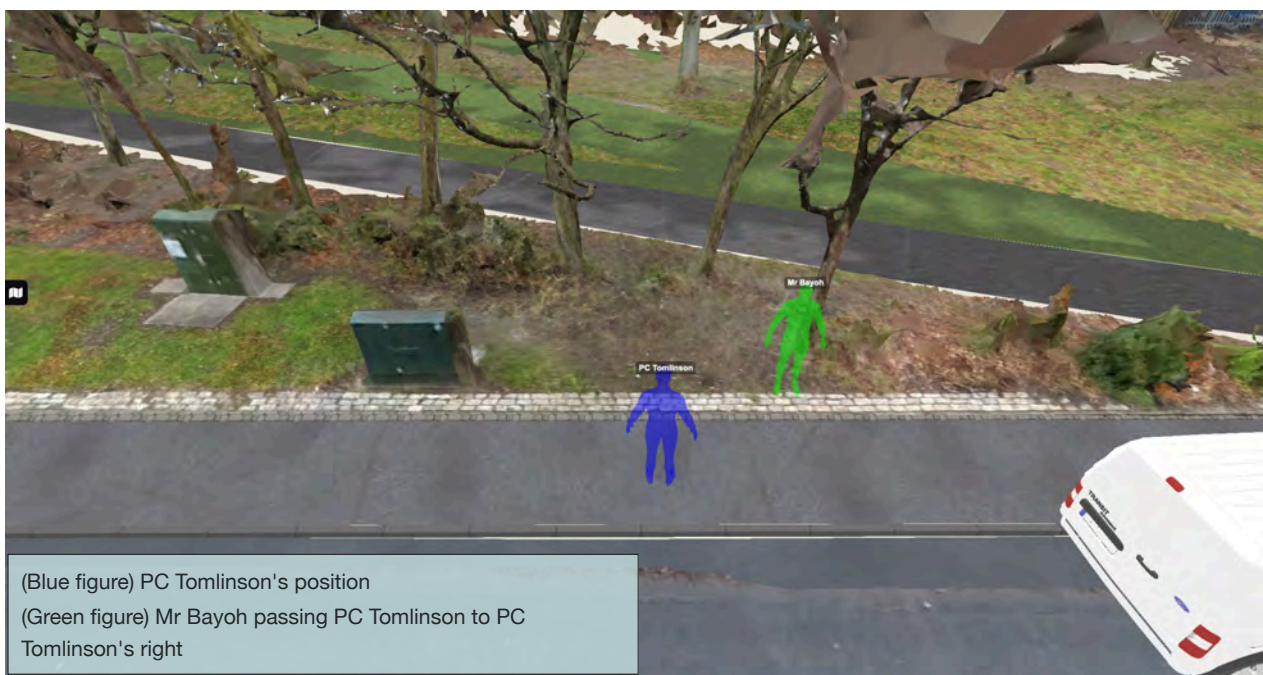


(b) Refined positions , PC Tomlinson (am) - 26/05/2022. From 02:53:00

Figure C.4: PC Tomlinson describes Mr Bayoh turning to face him after Pava Deployment

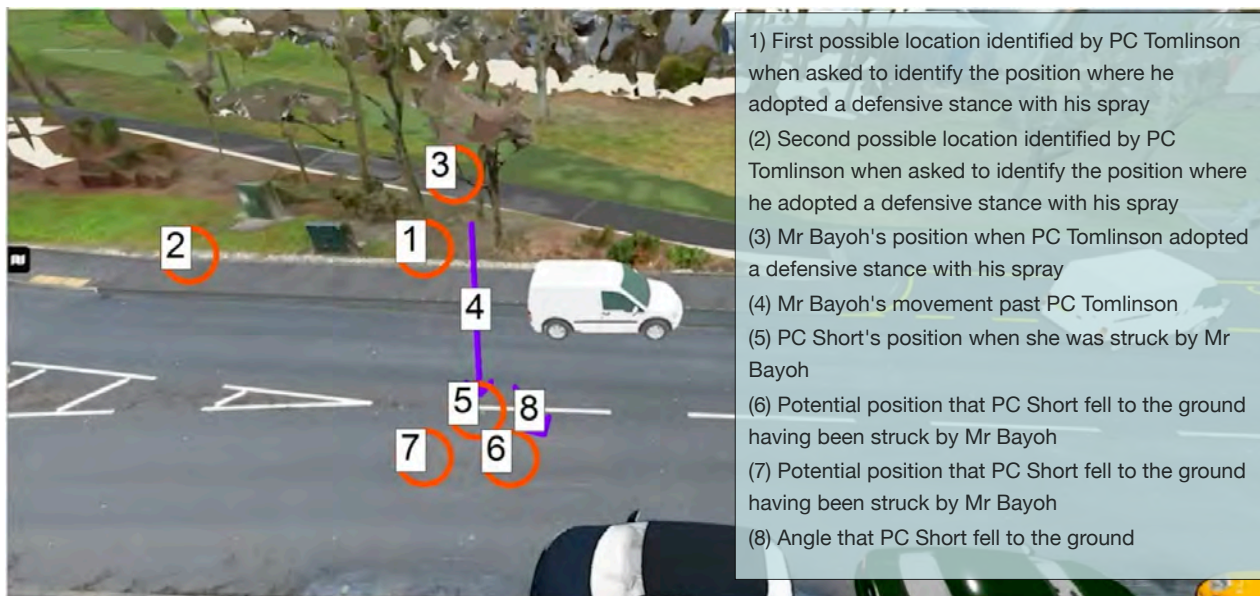


(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. Positions 1 -3 from 02:29:15. Positions 4 - 8 from 02:46:15

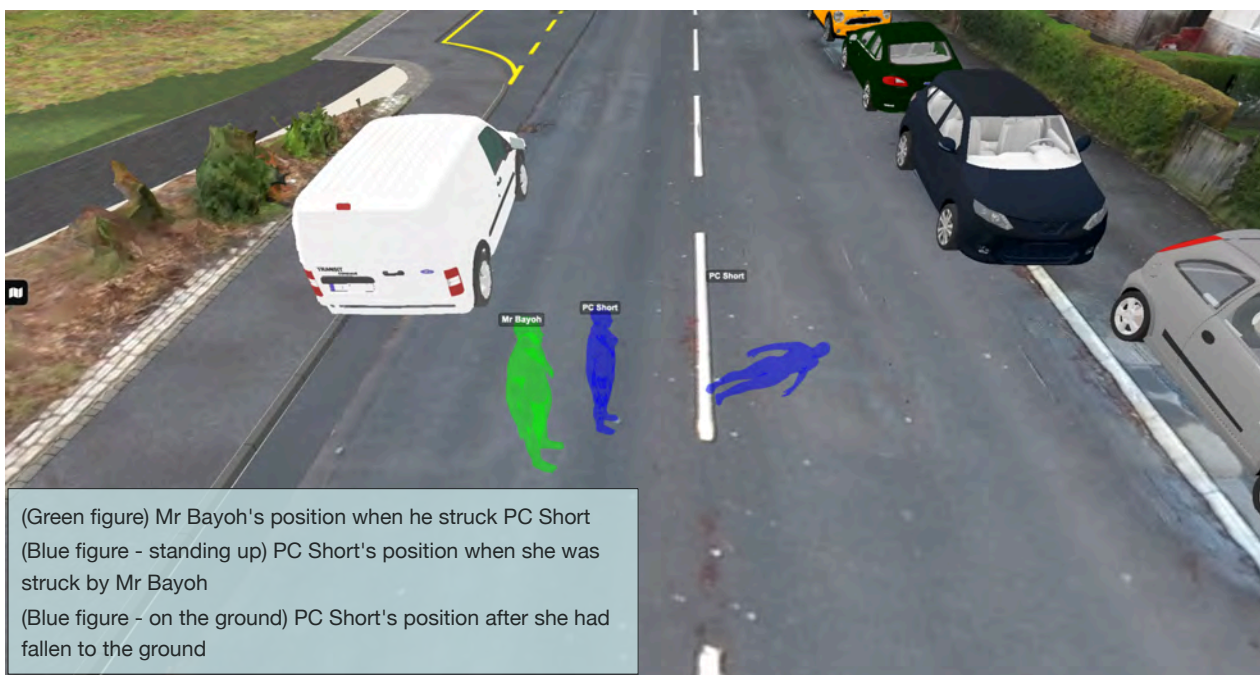


(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 02:57:05.

Figure C.5: PC Tomlinson describes Mr Bayoh passing him to his right

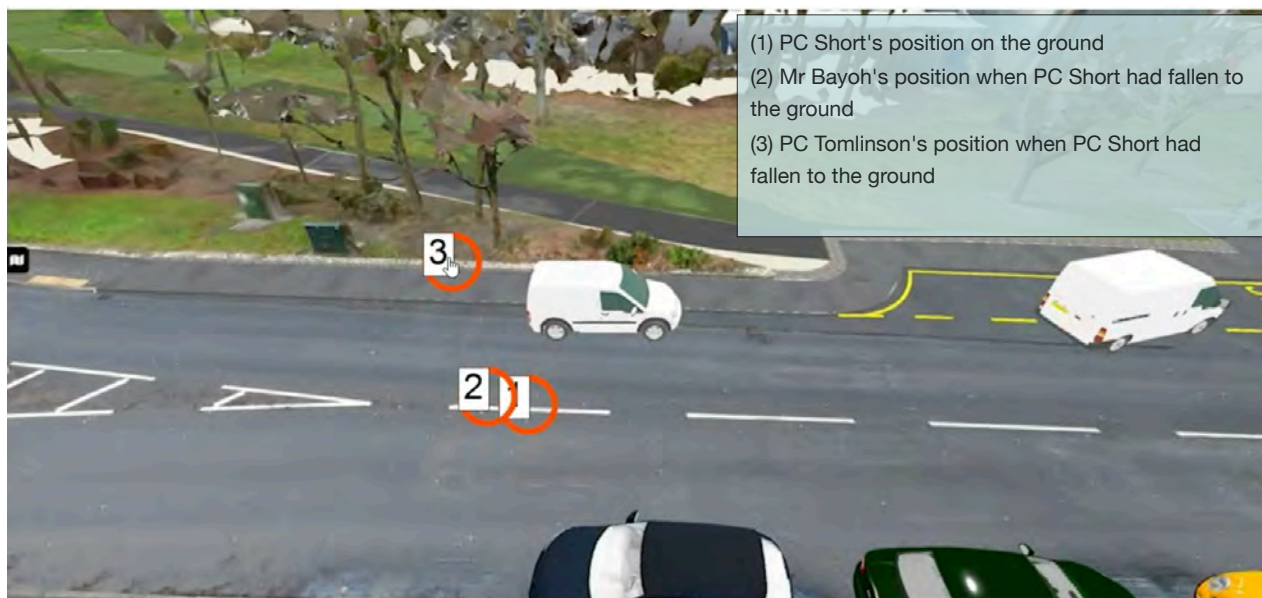


(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. Positions 1 -3 from 02:29:15. Positions 4 - 8 from 02:46:15

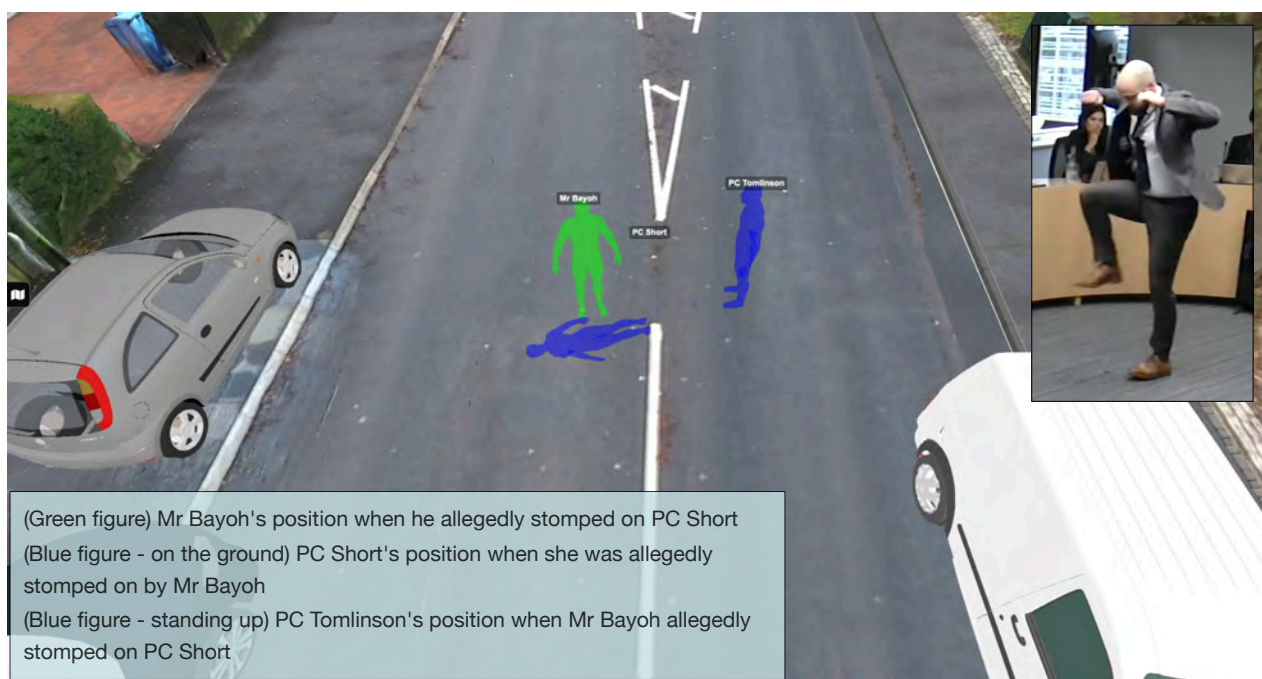


(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 02:59:50.

Figure C.6: PC Tomlinson describes PC Short being struck and going to the ground

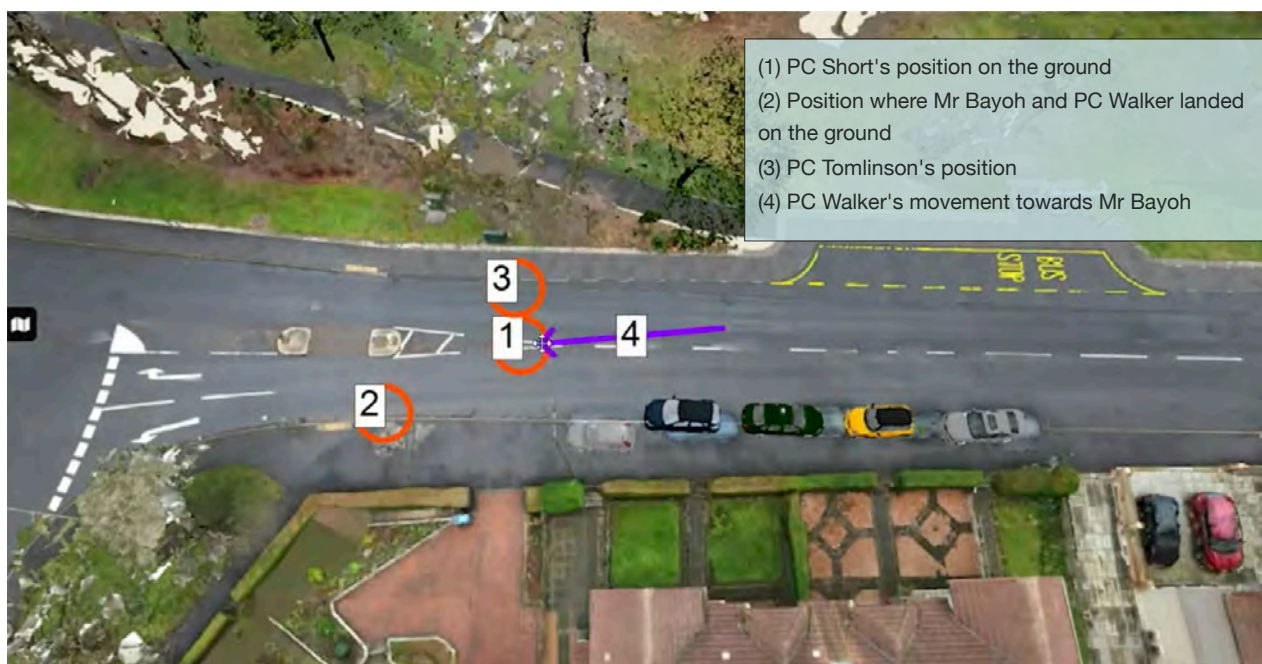


(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. From 02:53:35.

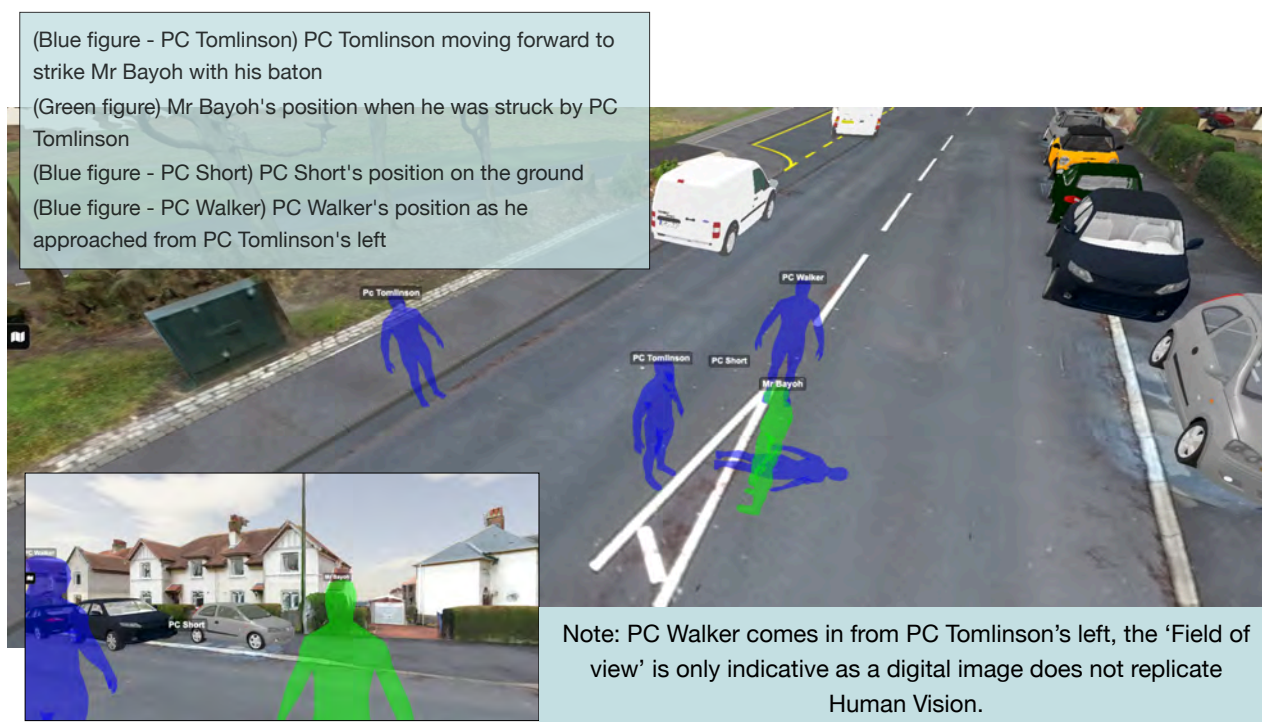


(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 03:05:20 - Inset PC Tomlinson demonstrating alleged stomp, PC Tomlinson (pm) - 25/05/2022. From 02:58:00.

Figure C.7: PC Tomlinson describes alleged PC Short stomp

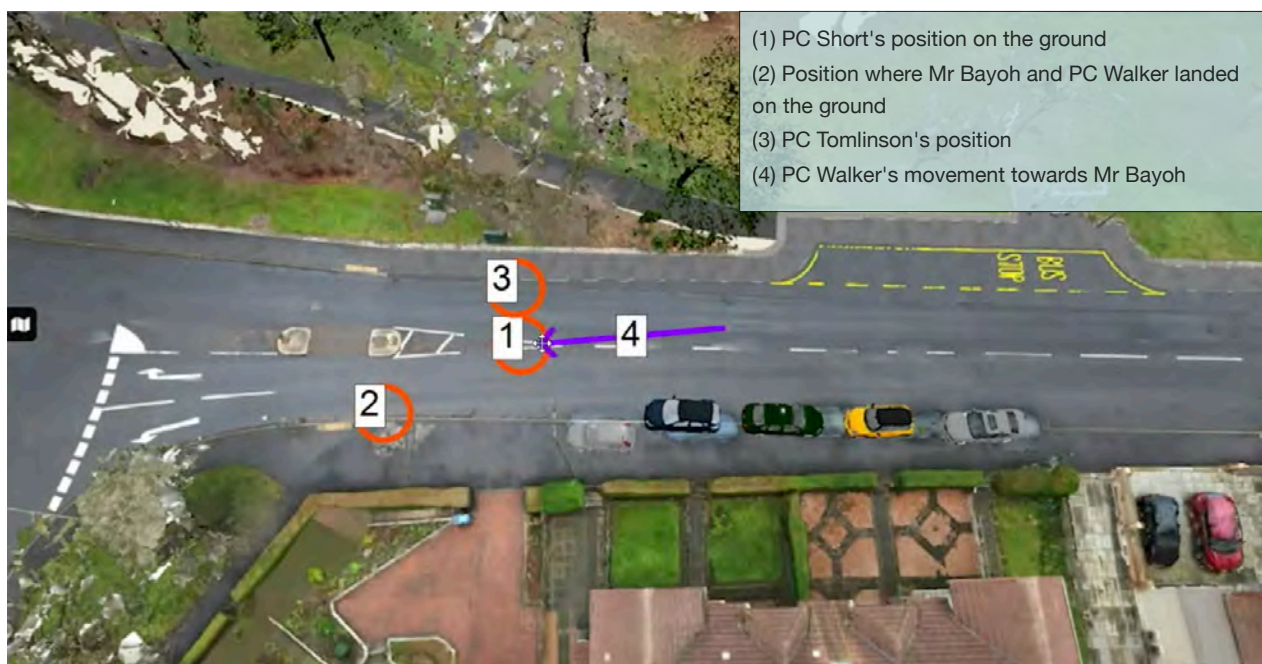


(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. Numbers 1 - 2 from 03:30:50. Numbers 3 - 4 from 03:36:00



(b) Refined positions, PC Tomlinson (am) - 26/05/2022. From 03:09:00. - Inset, Tomlinson's Field of view

Figure C.8: PC Tomlinson describes moving towards and striking Mr Bayoh



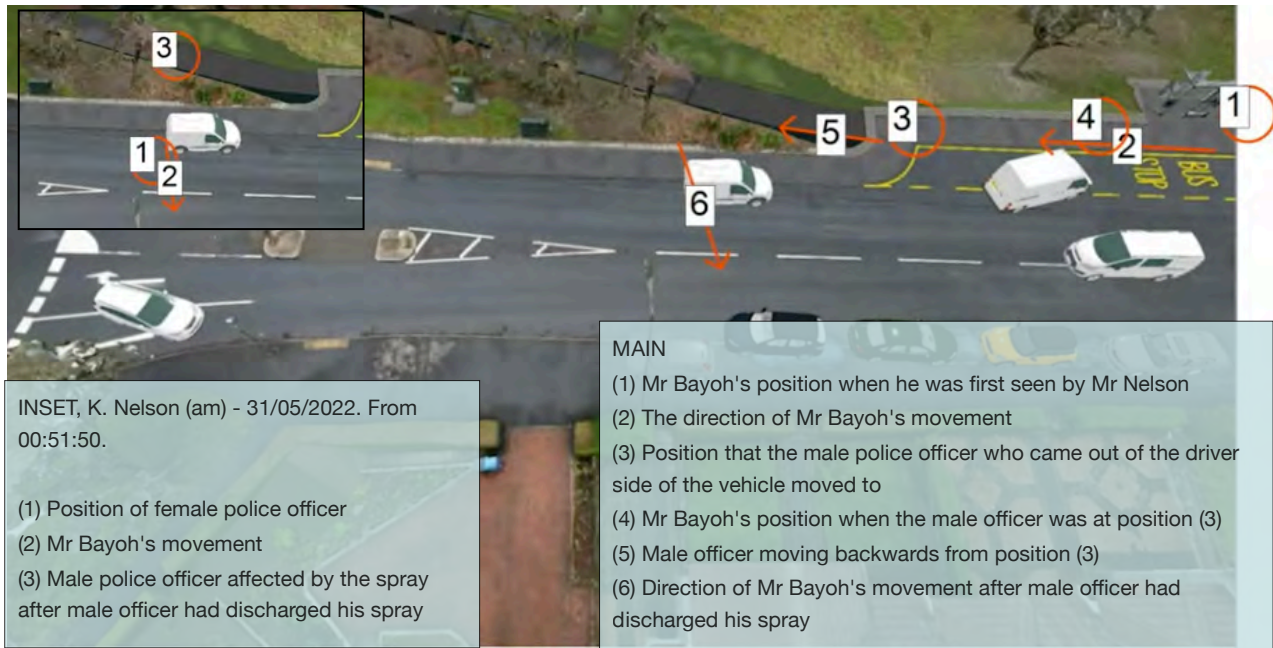
(a) Initial locations identified, PC Tomlinson (pm) - 25/05/2022. Numbers 1 - 2 from 03:30:50. Numbers 3 - 4 from 03:36:00



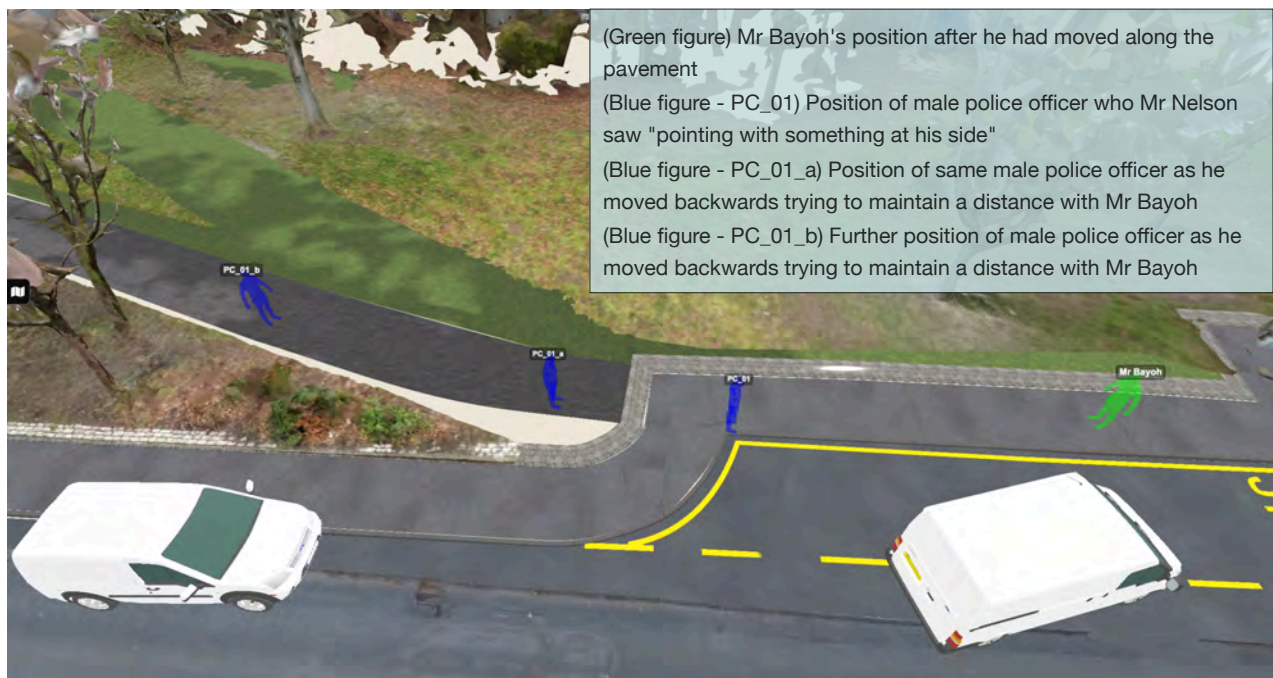
(b) Refined positions, Akhtar Ali and PC Tomlinson (pm) - 26/05/2022. From 00:44:20.

Figure C.9: PC Tomlinson describes Mr Bayoh being taken to ground

APPENDIX D - MR K. NELSON'S EVIDENCE



(a) Initial locations identified, Kevin Nelson (am) - 31/05/2022. Positions 1 - 2 00:40:00. Positions 3 - 5 from 00:43:50. Position 6 from 00:48:55



(b) Refined positions, Kevin Nelson (am) - 31/05/2022. From 02:10:00.

Figure D.1 Mr Nelson describes people positions as police arrive

(1) Position that female police officer stumbled or fell to the ground

(2) Mr Bayoh's position when the female police officer fell to the ground



(a) Initial locations identified, Kevin Nelson (am) - 31/05/2022. From 00:59:10



(Green figure) Mr Bayoh's position when he struck the female police officer
(Blue figure) Female police officer's position when she was struck by Mr Bayoh

(b) Refined positions, Kevin Nelson (am) - 31/05/2022. From 02:14:00

Inset (c) Field of view from window, Kevin Nelson (am) - 31/05/2022. From 02:14:00

Inset (d). Demonstration of how female officer was struck by Mr Bayoh. Kevin Nelson (am) - 31/05/2022. From 02:04:50.

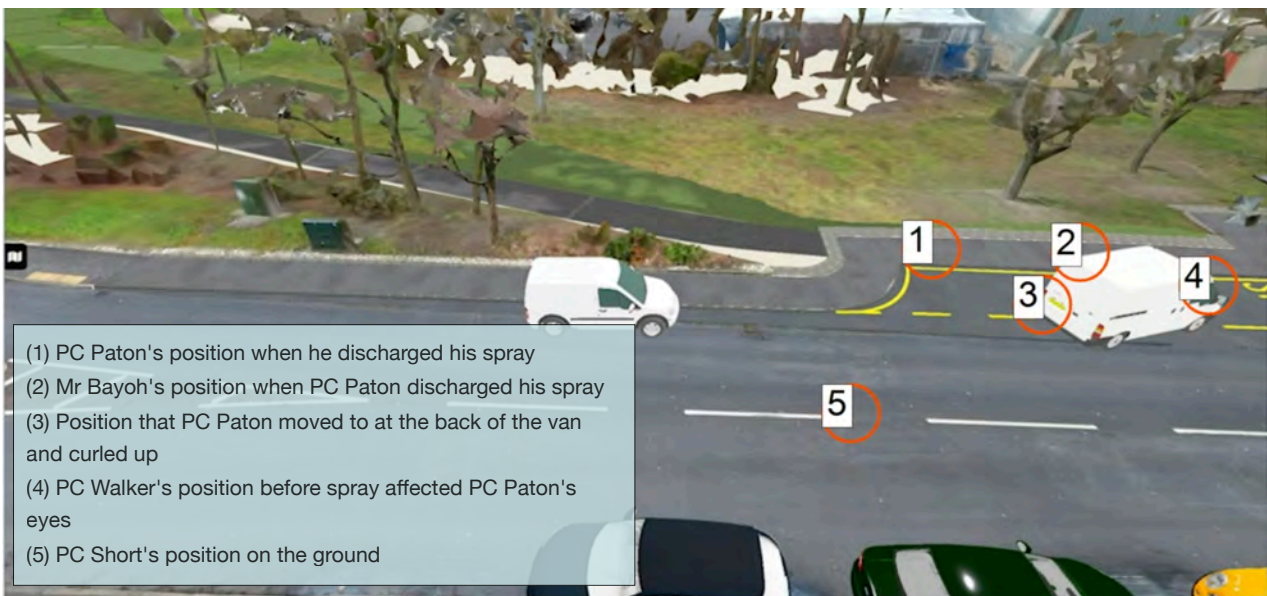
Figure D.2, Mr Nelson describes the location of the female officer as she stumbled and fell

APPENDIX E - PC PATON'S EVIDENCE



Initial locations identified, Alan Paton (am) - 21/06/2022. From 00:40:50.

Figure E.1 PC Paton describes Mr Bayoh's position as the van arrives



Initial locations identified, (Alan Paton (am) - 21/06/2022. From 01:12:30

Figure E.2, PC Paton describes the location of people after leaving the van



Initial locations identified, Alan Paton (am) - 21/06/2022. From 01:22:30.

Figure E.3, PC Paton describes the location of the restraint