

# Digital Reconstruction

Sheku Bayoh Inquiry

# DIGITAL RECONSTRUCTION

## Methodology and Process

- (a) Advanced Laser Imaging - History / Experience
- (b) Terms of Reference
- (c) General Principles of Reconstruction
- (d) Digital Twin Capture
- (e) Objective Evidence Assessment and Visualisation
- (f) Subjective Evidence Assessment and Visualisation

# Who we are..



Advanced Laser Imaging Ltd - Established 2013  
Leaders in use of 3D Laser Scanning and Photogrammetry  
for Policing and Security investigations.

Offering specialist analysis products as a service.



Mark DeGiovanni  
3D Modelling &  
Photogrammetric Analysis  
Technical Director



David Mercel  
3D Laser Scanning & Processing  
Chief Technical Officer

## History

Metropolitan Police Service - 2007 to 2013

- Computer Aided Modelling Bureau

7/7 bombings, Diana Inquest, Lee Rigby Murder, M5 Motorway Crash, Vauxhall Helicopter Crash  
Security planning for Royal Wedding & G20 Summit, London Excel

# Advanced Laser Imaging - Last 3 years

## INSURANCE / OTHER LEGAL

Car Insurance - Road Traffic Accidents

Fire and Explosion - Loss of life

Damage to Property

**36.8%**

## POLICE / PROSECUTION

Murder Investigations

Feasibility studies

Ballistic Lines of sight

Scene familiarisation

People tracking

CCTV Analysis

Injury Mapping / Visualisation

Cold Case Anlaysis

**28.9%**

## DEFENCE / POLICE & MILITARY OMBUDSMAN

Murder Charges

Rape Charges

Feasibility studies

Ballistic Lines of sight

Scene familiarisation

CCTV Analysis

**23.7%**

## DIGITAL TWIN RECONSTRUCTION

Asset Conditioning

Retail

Health and Safety

**5.2%**

## INQUESTS Historic Site Reconstruction

**2.6%**

## RESEARCH Business to Business Government grant

**2.6%**

# Terms of Reference

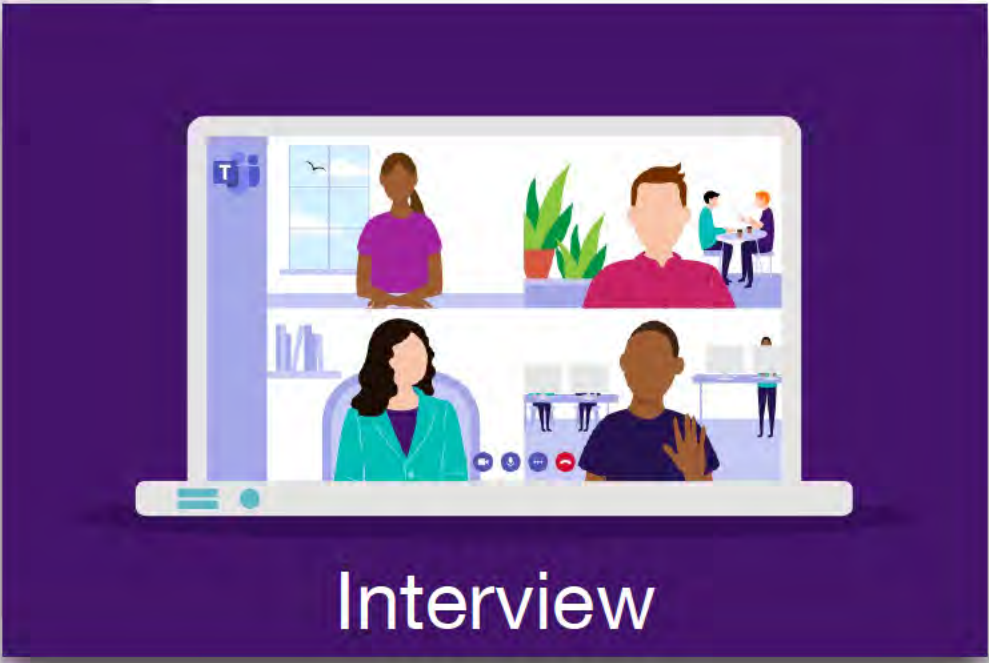
“The Inquiry, based in Scotland and constituted under the Inquiries Act 2005, is investigating the death of Sheku Bayoh while being restrained by Police Scotland in 2015. Further details regarding the Inquiry can be found on our website:

<https://www.shekubayohinquiry.scot/>

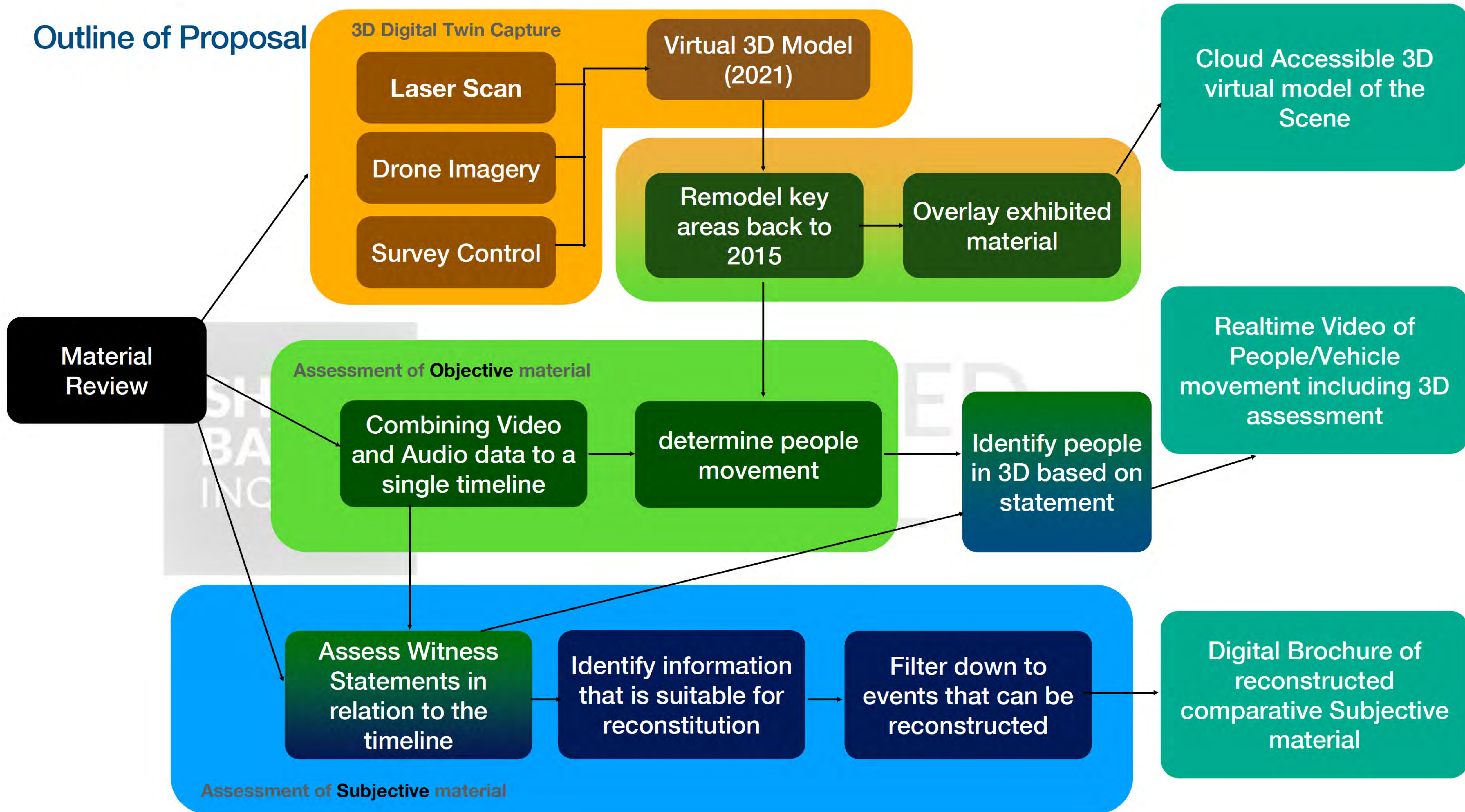
The Inquiry is considering commissioning a digital reconstruction of events relating to the death of Mr Bayoh and is seeking a suitably skilled contractor to provide expert advice to the Inquiry, a quote, and then potentially take forward the reconstruction work.”

Provided by ALI

SHEKU BAYOH INQUIRY  
RESTRICTED MATERIAL



# Outline of Proposal



## Objective Material

Information that is not influenced by personal feelings or opinions in the representation of the facts.

### Visual



CCTV



DashCam



Mobile



Crime Scene  
Photography

### Measured



3D Survey



ARLS  
(GPS)

### Audio



999/101  
Calls



Airwave

### Expert / Investigation Statements (Factual)



## Subjective Material

Information that is based on or is influenced by a person's feelings, tastes, opinions or experiences

### Public Statements

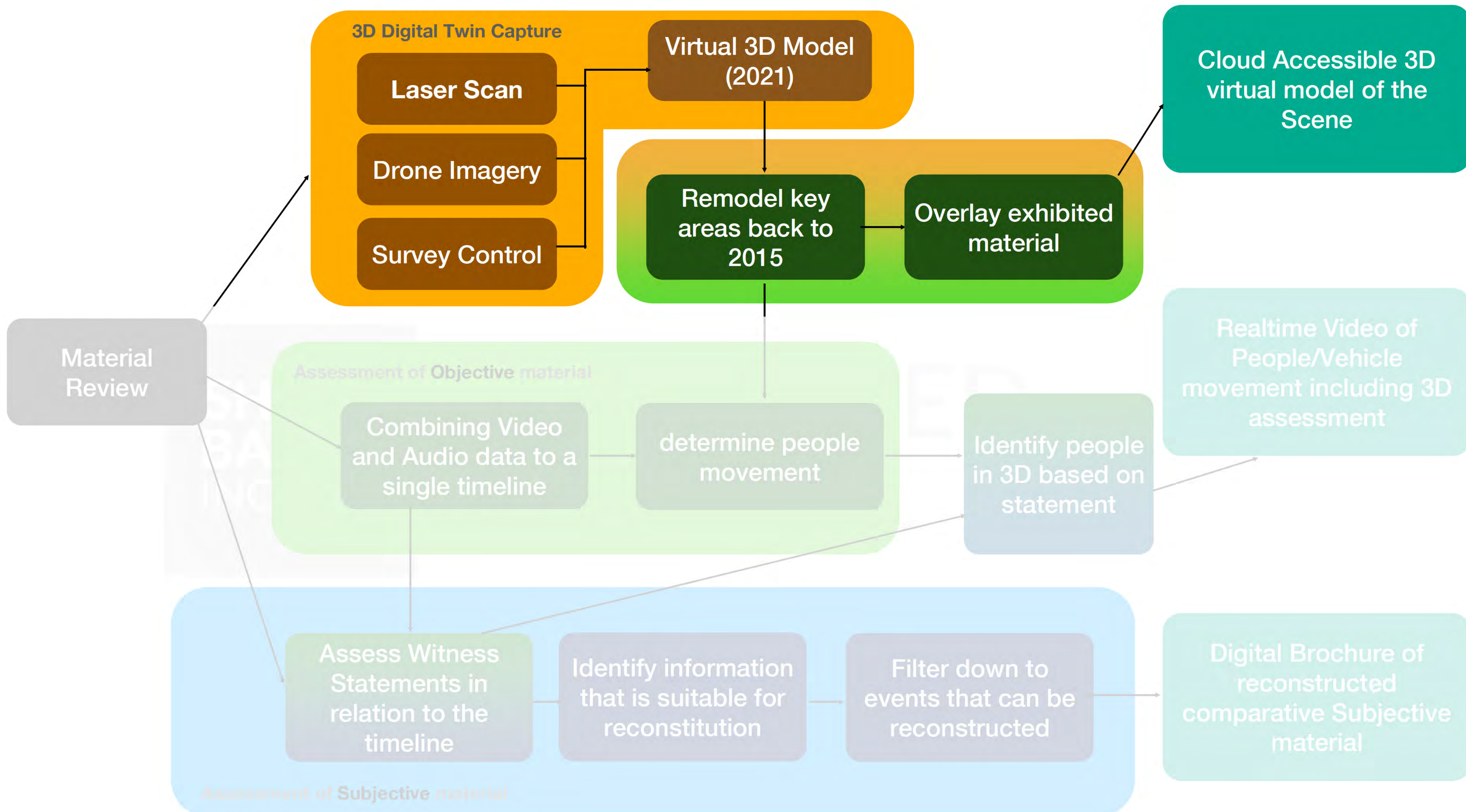


### Police Response Statements / Diagrams



### Expert Statements (Opinion)





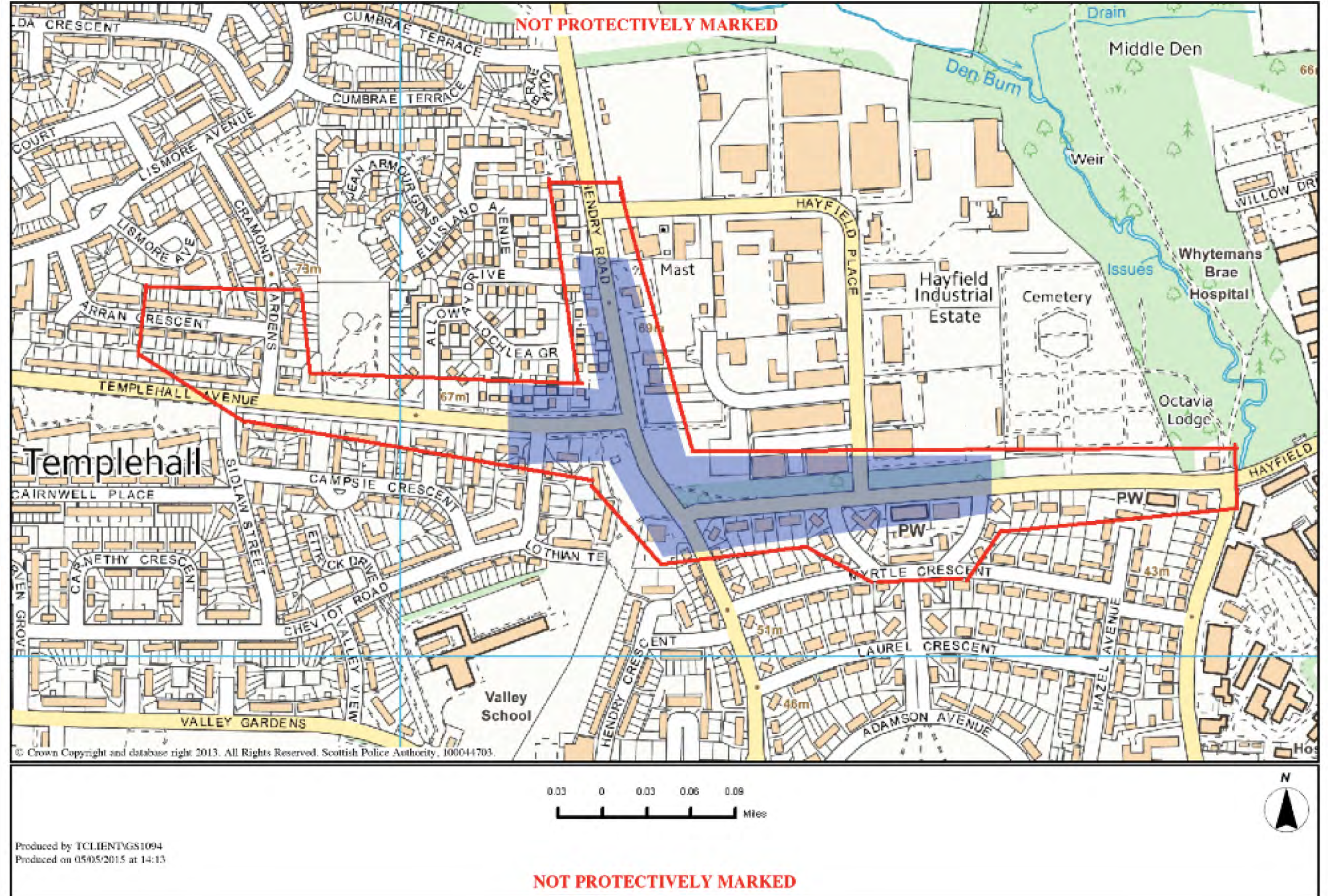


# Area of Consideration / Capture

 CCTV Parameter Map

 Area to be Surveyed

SHEKU  
BAYOH  
INQUIRY



## Laser Scan Data

>80 Scan positions

Faro S150 Laser Scanner

- Range: 0.6-150m
- Accuracy: 2mm @10m, 3.5mm @25m
- 300°vertical / 360° horizontal
- Dual Axis Compensator, Compass, GNSS

## UAV Scene Capture

>2500 Images

DJI Mini 2 UAV

- Weight: < 249 g
- Sensor: 1/2.3" CMOS
- Effective Pixels: 12 MP
- 35 mm format equivalent: 24 mm

## Survey Control

>500 Points

Trimble S7 & GNSS

- Accuracy Prism: 1.0 mm + 2 ppm
- Accuracy DR: 2.0 mm + 2 ppm
- OSBG36 (EPSG 27700)

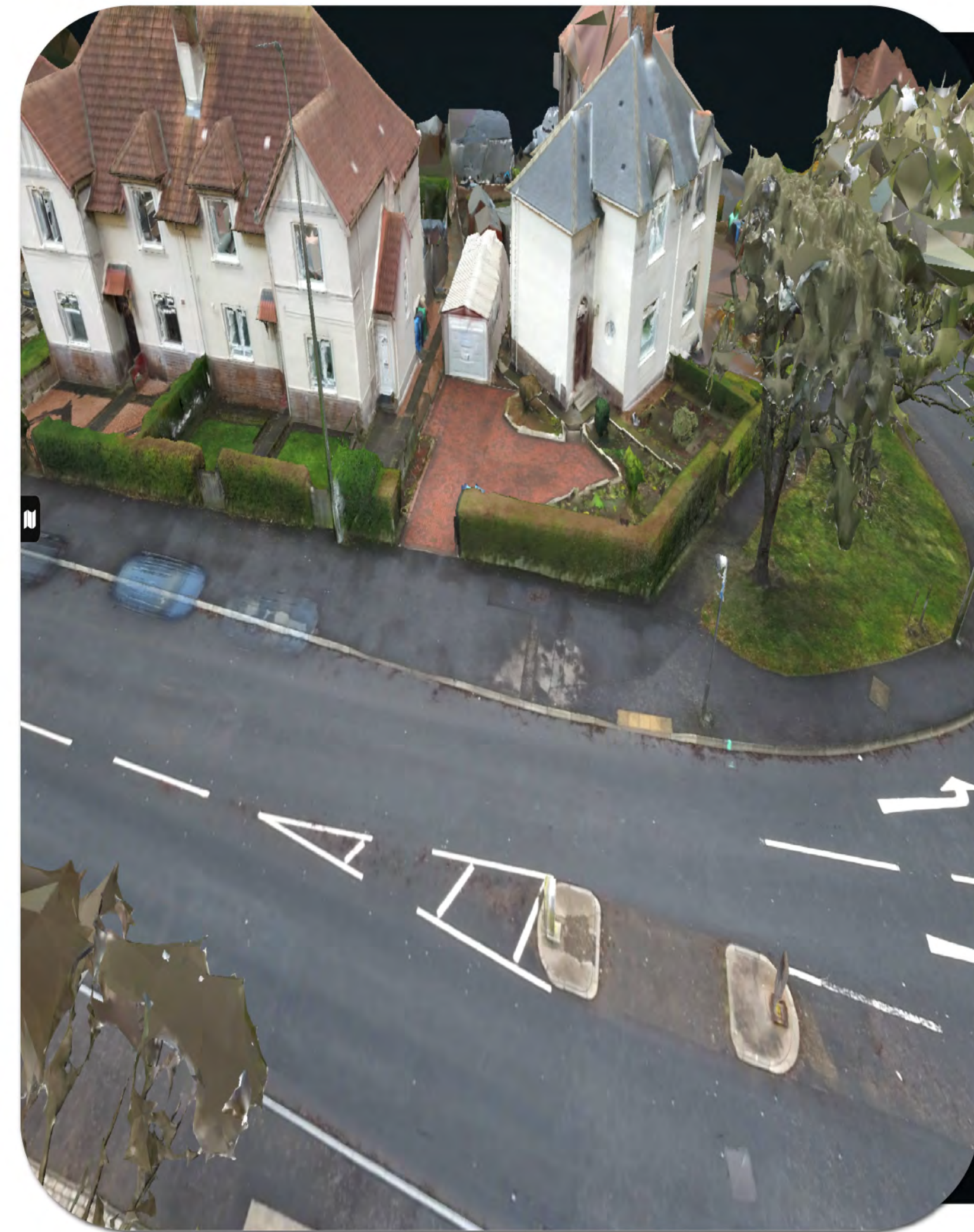
3D Digital Twin Capture

3D Model Generated



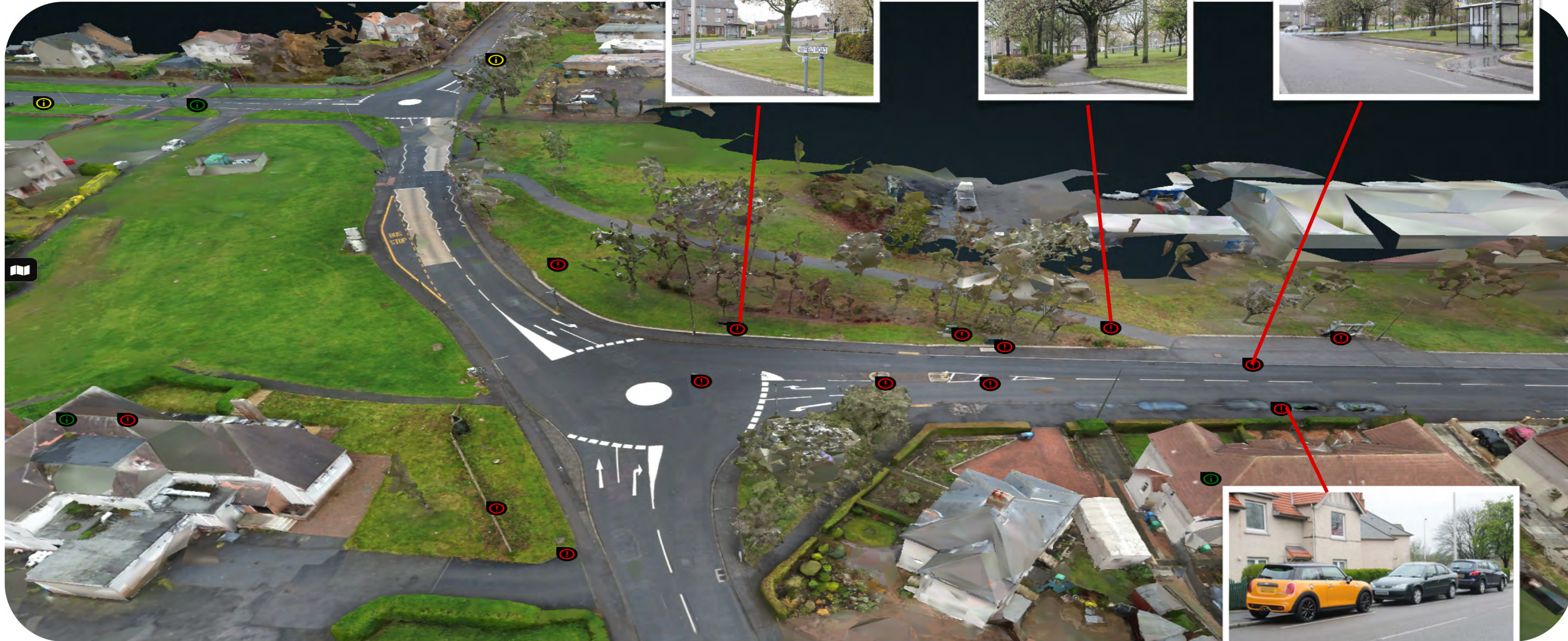
3D Digital Twin Capture

3D Model Generated



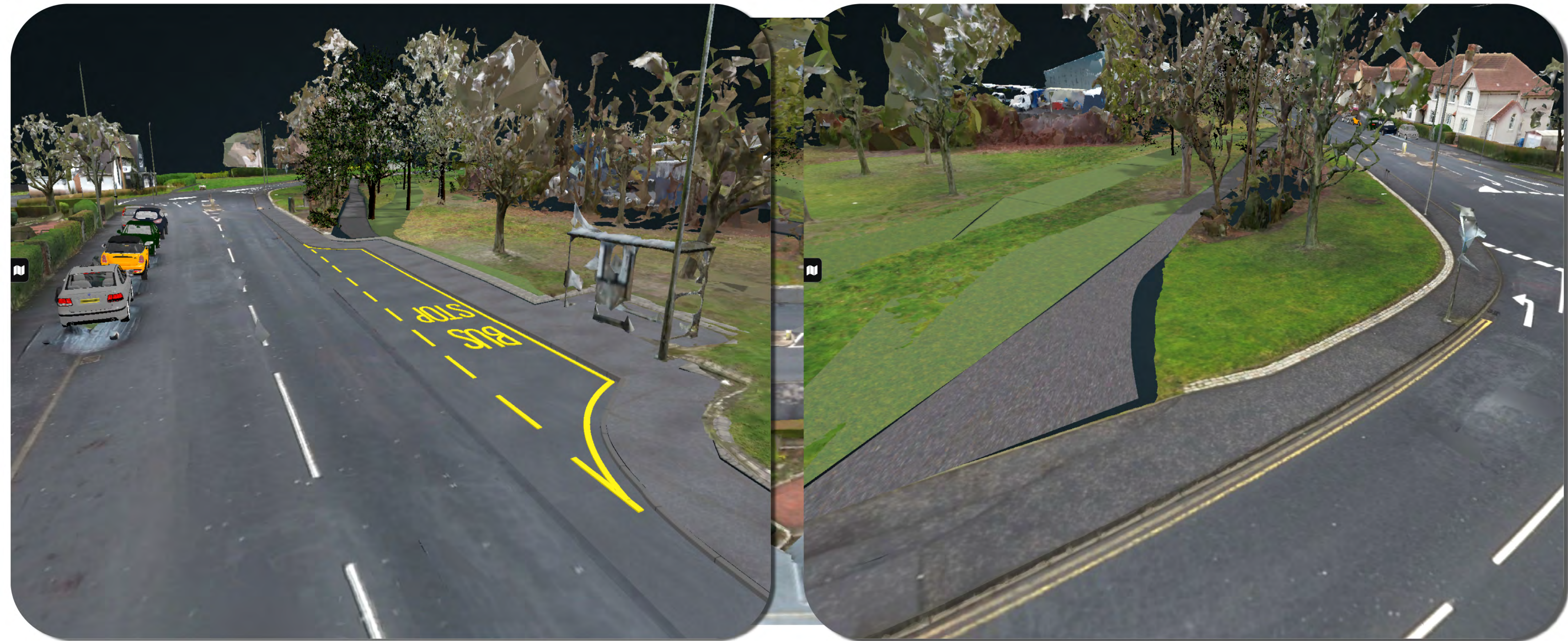
# Remodelling Scene

# Scene Variations

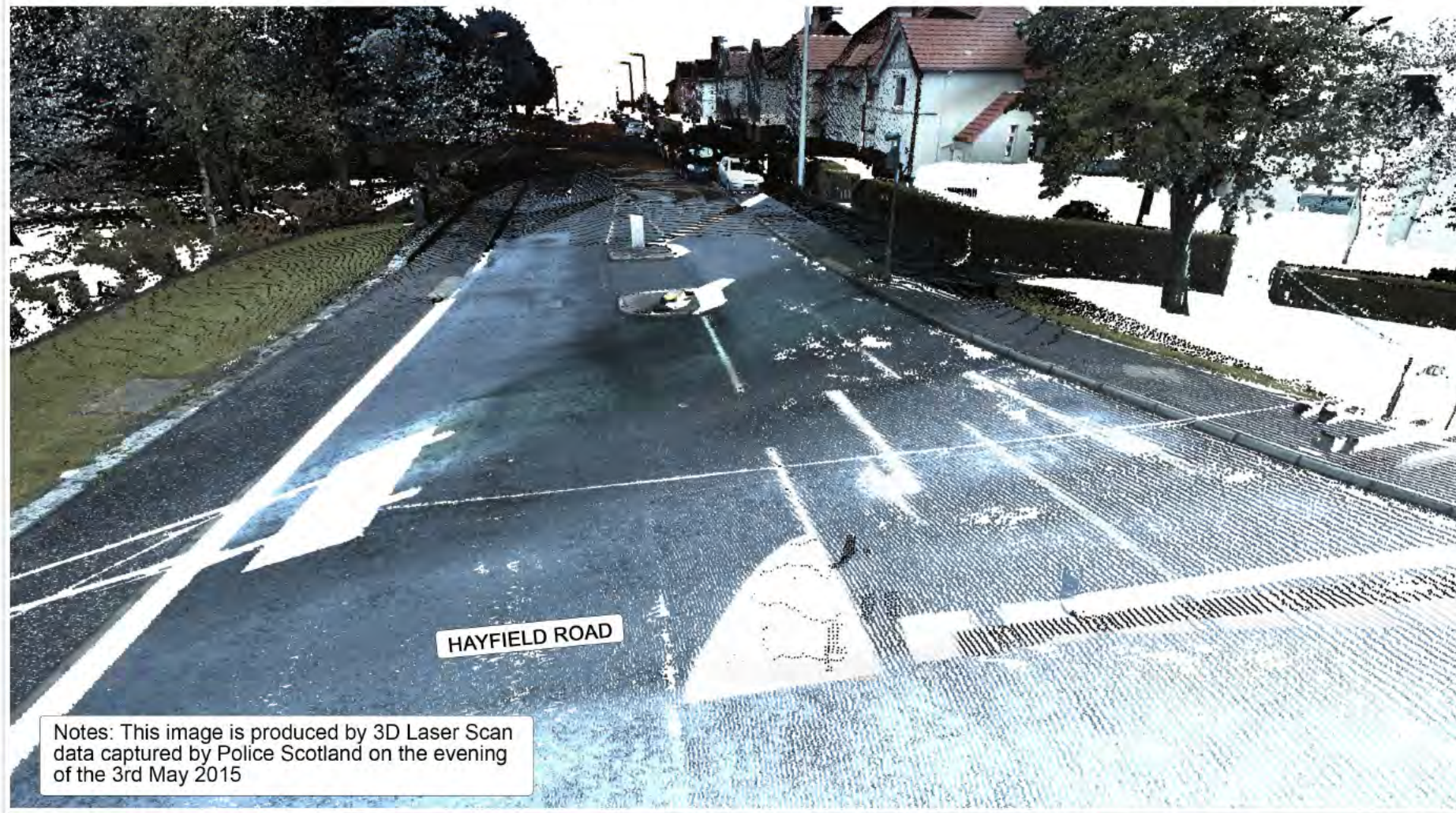


Remodelling Scene

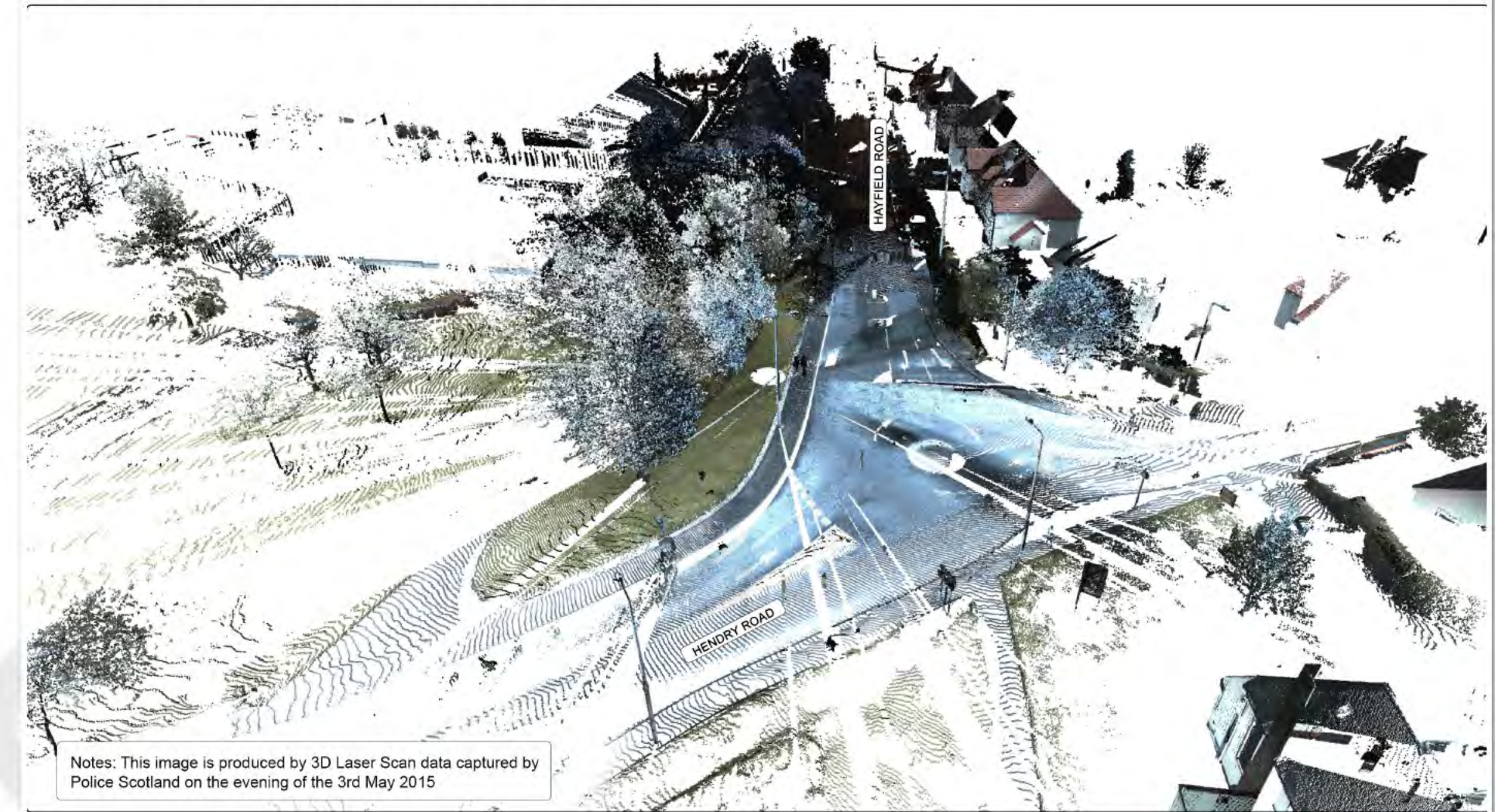
Hybrid Model



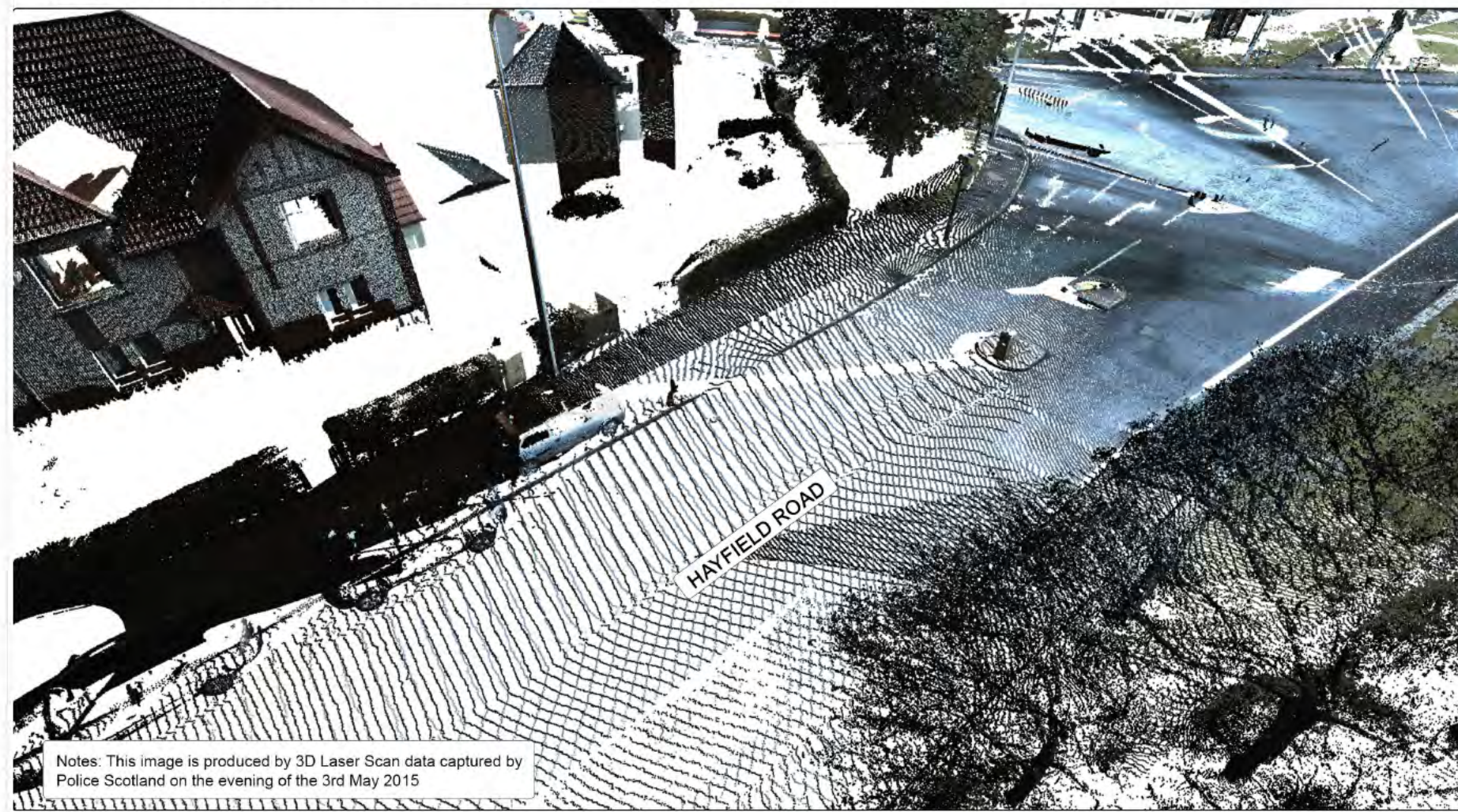
View 01 - From Hendry Road Junction down Hayfield Road



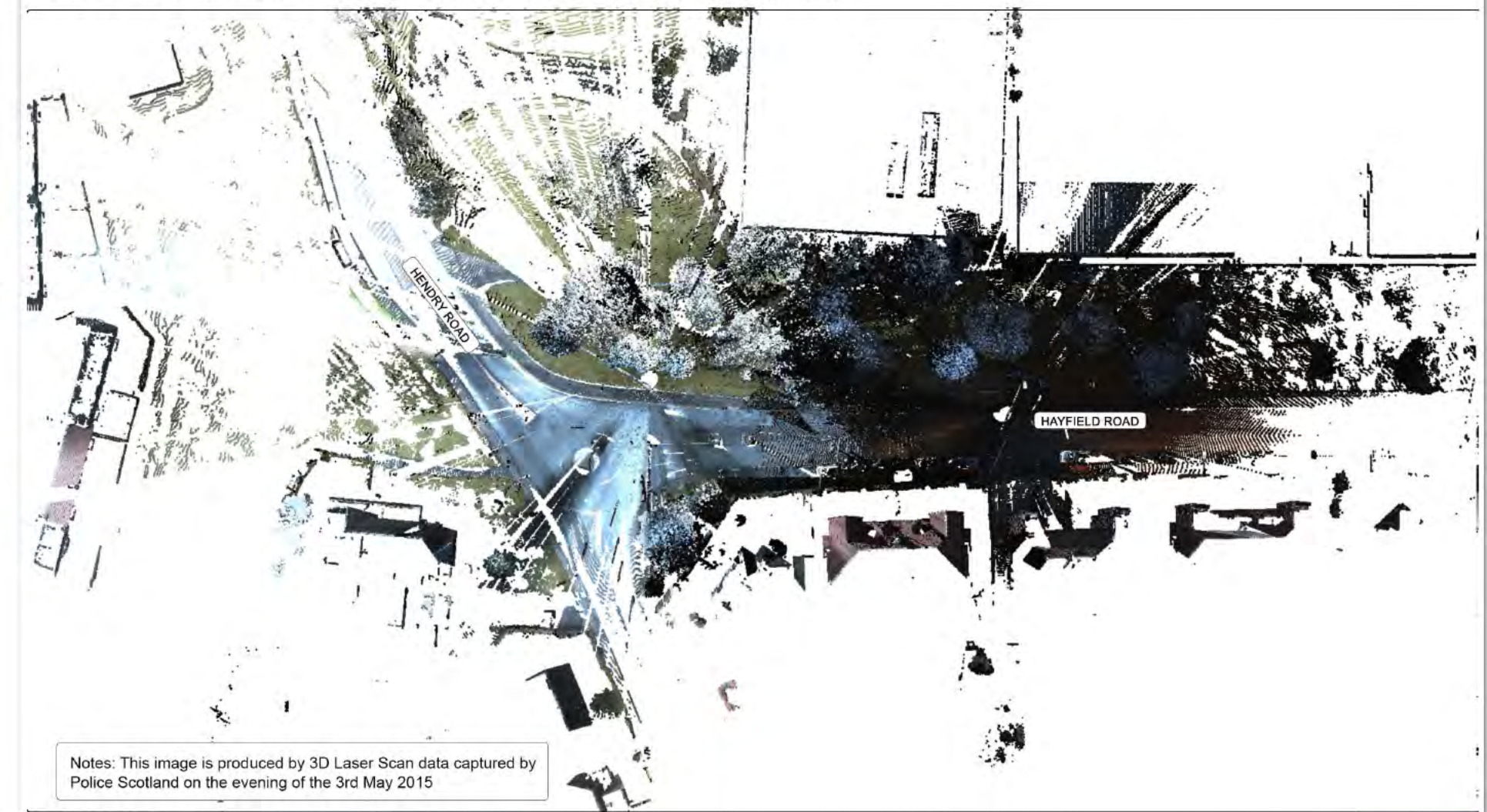
View 03 - Overview of Hendry Road and Hayfield Road Junction



View 02 - From Hayfield Road Toward the Junction with Hendry Road



View 04 - Overview of Hendry Road and Hayfield Road Junction - Birdseye view



Overlay existing Exhibits

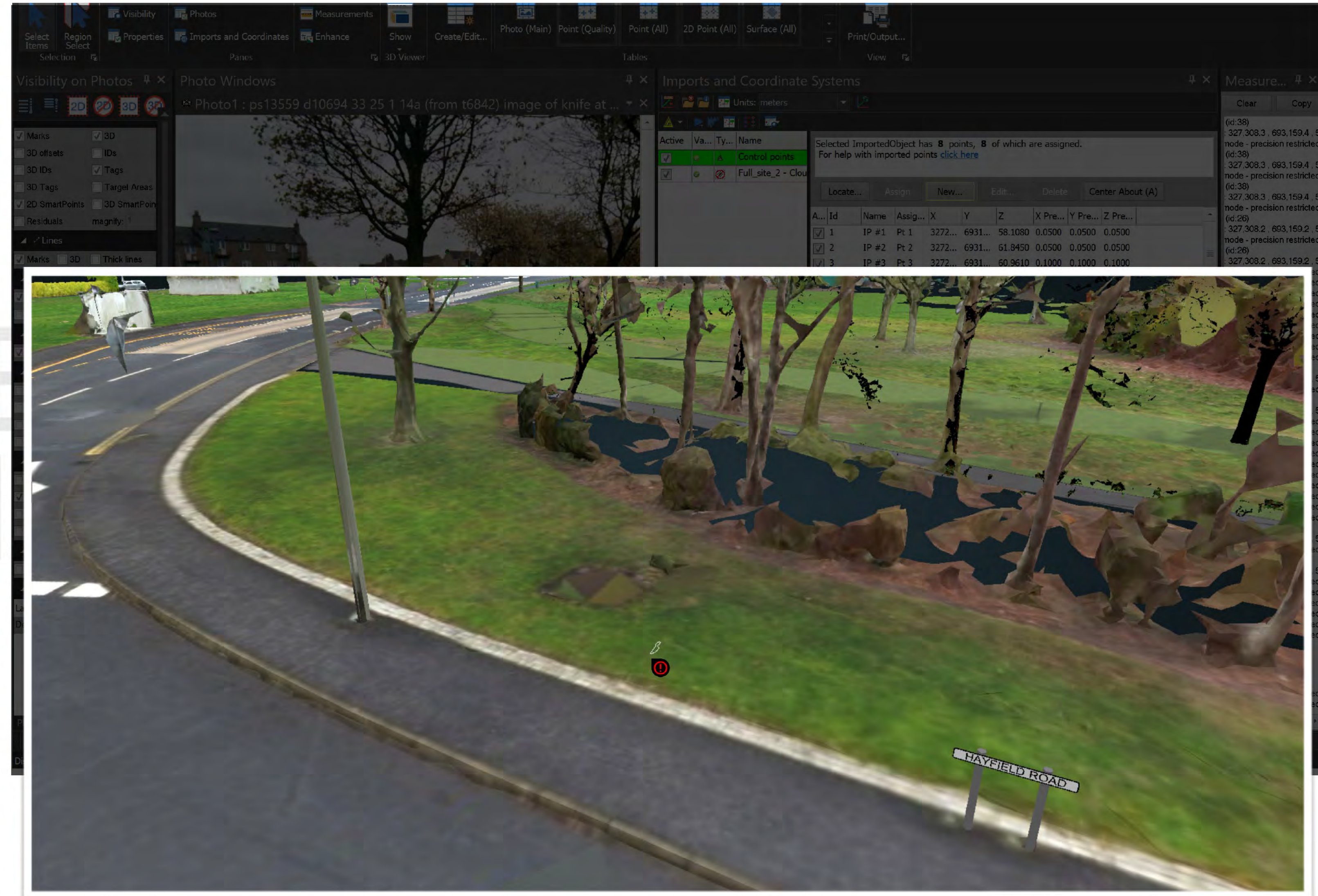
# 2015 Laser Scan Data





# Objective Assessment

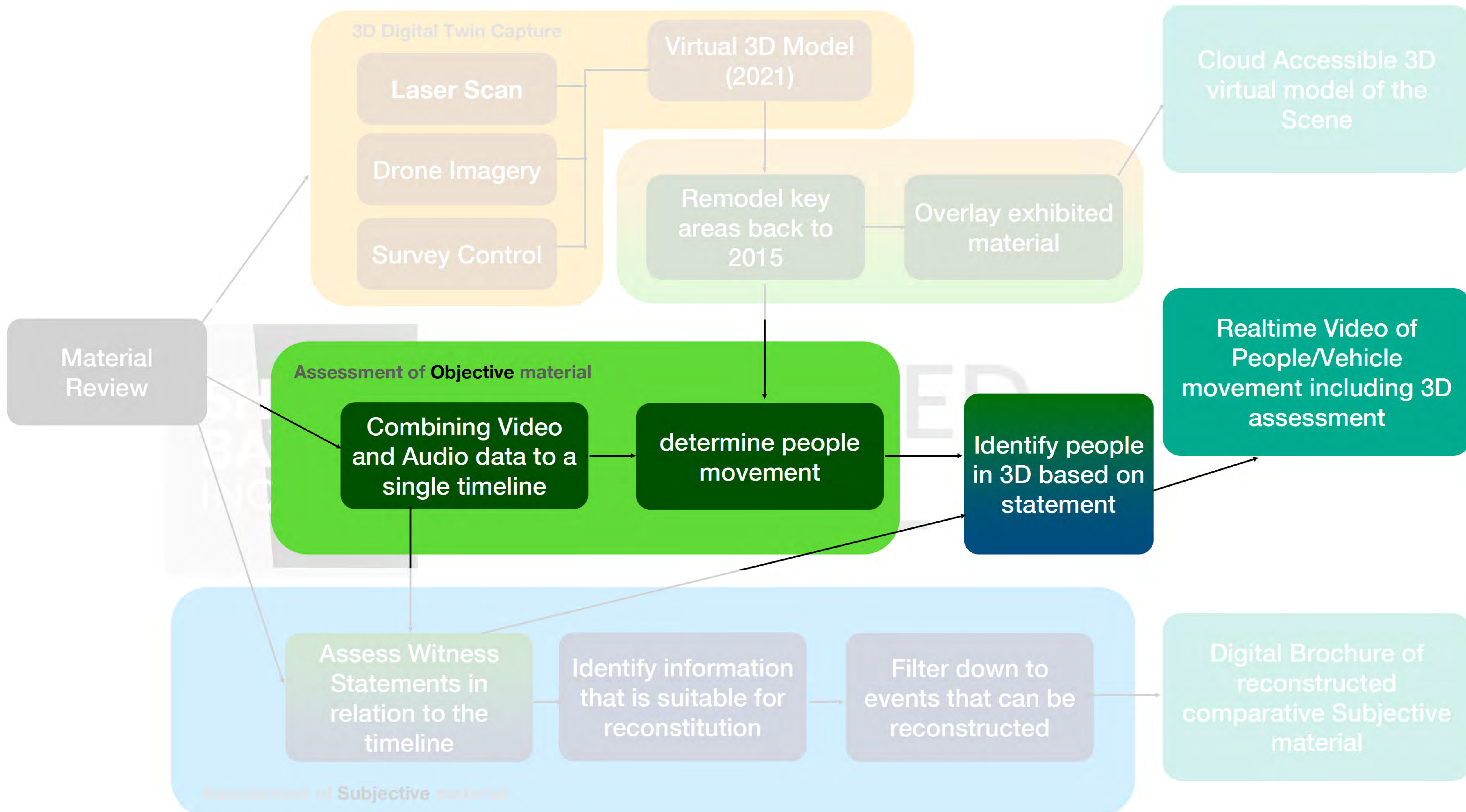
# Knife Location



Final 3D Interactive Model

**SHEKU  
BAYOH  
INQUIRY**

**DEMO**  
RESTRICTED  
MATERIAL



# Objective Assessment



Gallagher Public House  
Officer 'Talking clock' check  
10mins 52 seconds slow



999 / 101 calls

Truncated to whole second

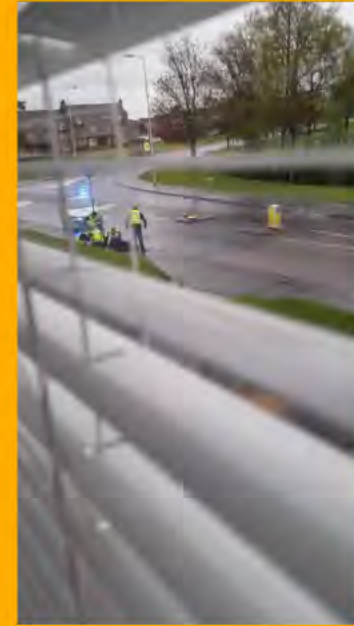


Airwave calls

Truncated to whole second

Known Timed Events

# Timing of Video / Audio



Snapchat-  
4027412658762379031



Snapchat-  
2800019487722441065



Snapchat-  
2154007213033099882

Partial Timed Events



RK Mobile Footage



HK DashCam Footage



Van Footage

Unknown Timed Events

# Objective Assessment

# Timing of Snapchat



999 / 101 calls

07:10:14

07:15:50

Calculated

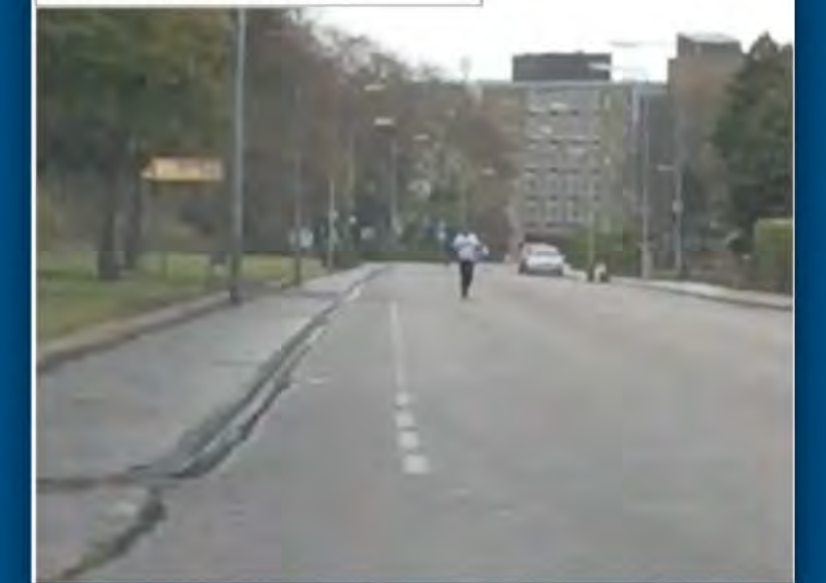


Validation

PIRC-01285 - Van driven by witness Grey

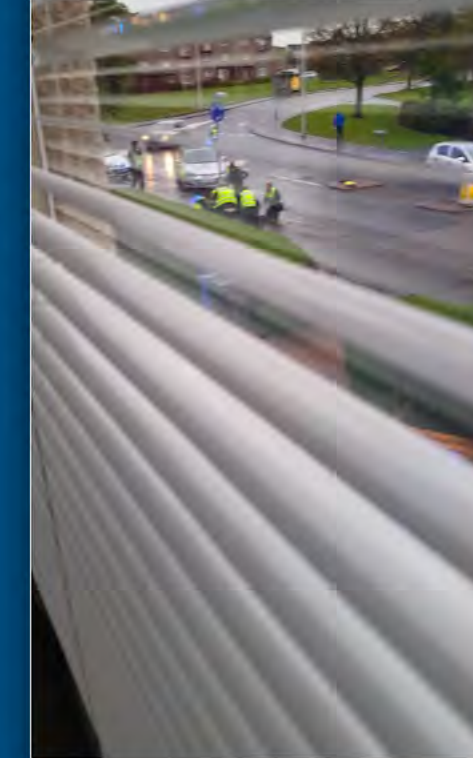


PIRC-01289 - Robson Kolberg's iPhone



Common Events

PIRC-03369 - Snapchat-2154007213033099882



PIRC-03370 - Snapchat-2800019487722441065



PIRC-03371 - Snapchat-4027412658762379031



Common Events + Thumbnail cache data

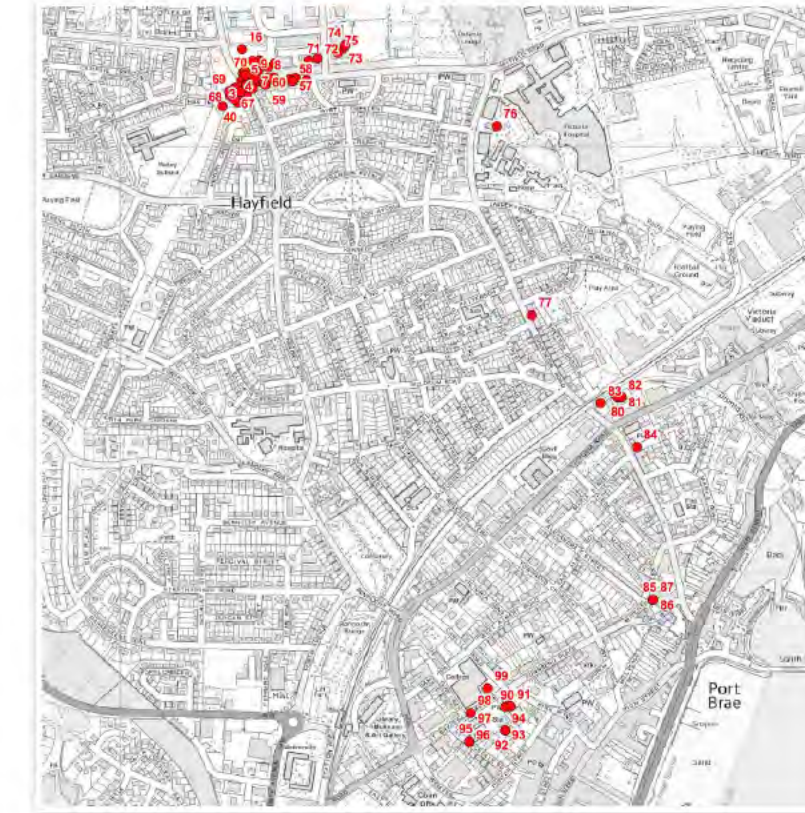
# Objective Assessment

# ARLS data

## ARLS RAW DATA

| Node    | Class        | Date Time           | Contents | Event ID | Event      | In fix | Latitude   | Longitude   | Speed | Bearing | Status | EWires | MWires | Location                     | Geofence | Data       |
|---------|--------------|---------------------|----------|----------|------------|--------|------------|-------------|-------|---------|--------|--------|--------|------------------------------|----------|------------|
| 6550203 | HANDPORTABLE | 03/05/2015 06:26:19 | 106      | 65       | Fix        | In Fix | 5607.5334N | 00310.2380W | 0     | 40      | 0      | 0      | 0      | At Hendry Road-Kirkcaldy     | 0        | 0006550203 |
| 6550203 | HANDPORTABLE | 03/05/2015 06:27:53 | 106      | 48       | Unknown 30 | In Fix | 5607.5462N | 00310.2387W | 0     | 42      | 0      | 0      | 0      | At Hendry Road-Kirkcaldy     | 0        | 0006550203 |
| 6550203 | HANDPORTABLE | 03/05/2015 06:28:34 | 74       | 42       | E11        | In Fix | 5607.5018N | 00310.3182W | 0     | 42      | 0      | 0      | 0      | At Lothian Terrace-Kirkcaldy | 0        | 0006550203 |
| 6550203 | HANDPORTABLE | 03/05/2015 06:29:04 | 106      | 65       | Fix        | In Fix | 5607.5240N | 00310.2833W | 0     | 113     | 0      | 0      | 0      | At Lothian Terrace-Kirkcaldy | 0        | 0006550203 |
| 6550203 | HANDPORTABLE | 03/05/2015 06:30:35 | 74       | 42       | E11        | In Fix | 5607.5329N | 00310.2562W | 0     | 113     | 0      | 0      | 0      | At Lothian Terrace-Kirkcaldy | 0        | 0006550203 |
| 6550203 | HANDPORTABLE | 03/05/2015 06:31:05 | 74       | 65       | Fix        | In Fix | 5607.5535N | 00310.2247W | 0     | 113     | 0      | 0      | 0      | At Hendry Road-Kirkcaldy     | 0        | 0006550203 |

## ARLS PLOTTED DATA



SHEKU  
BAYOH  
INQUIRY

RESTRICTED  
MATERIAL

<https://www.gps.gov/systems/gps/performance/accuracy/#:~:text=Learn%20more,How%20accurate%20is%20GPS%20for%20speed%20measurement%3F,interval%2C%20with%2095%25%20probability.>

(Automatic Resource Location System)

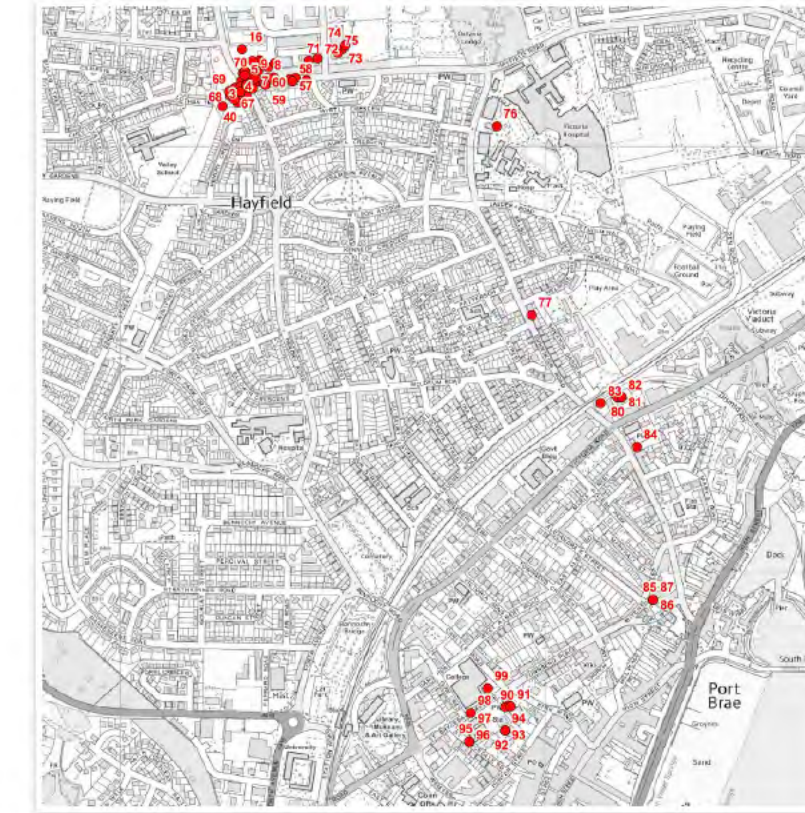
# Objective Assessment

# ARLS data

## ARLS RAW DATA

| Node    | Class        | Date Time           | Contents | Event ID | Event      | In fix | Latitude   | Longitude   | Speed | Bearing | Status | EWires | MWires | Location                     | Geofence | Data       |
|---------|--------------|---------------------|----------|----------|------------|--------|------------|-------------|-------|---------|--------|--------|--------|------------------------------|----------|------------|
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## ARLS PLOTTED DATA

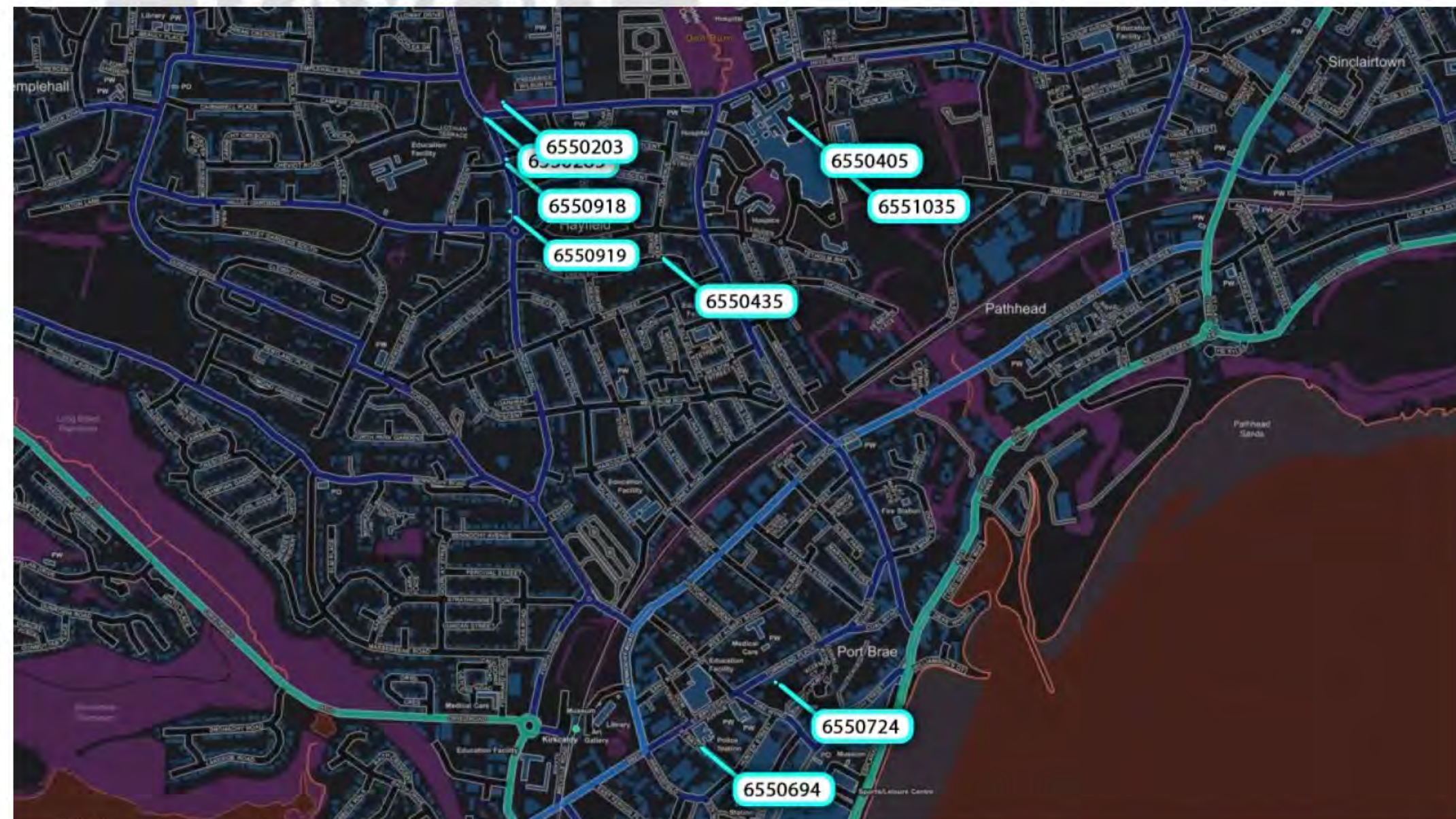


SHEKU  
RAYOU

RESTRICTED  
TRIAL

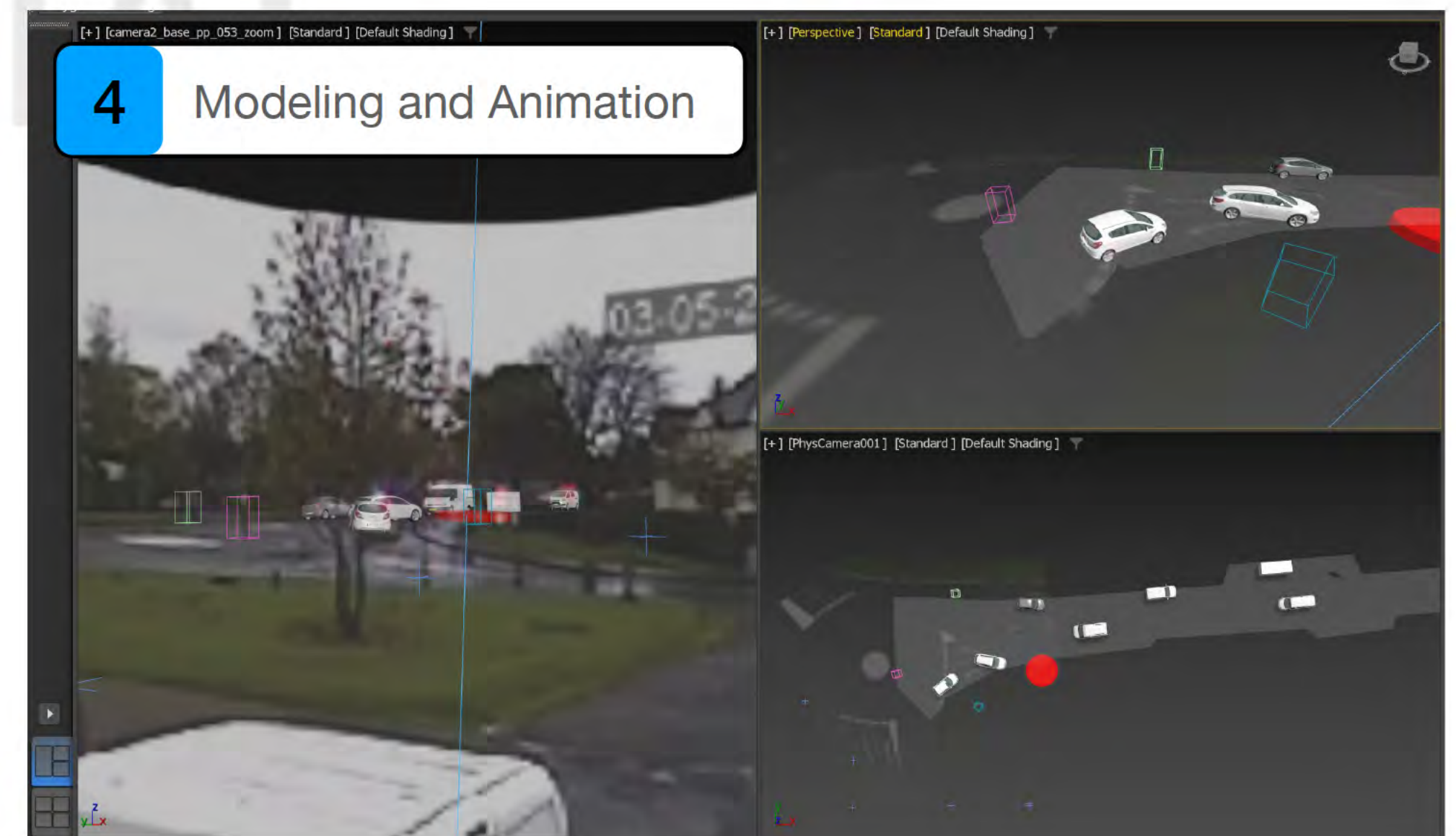
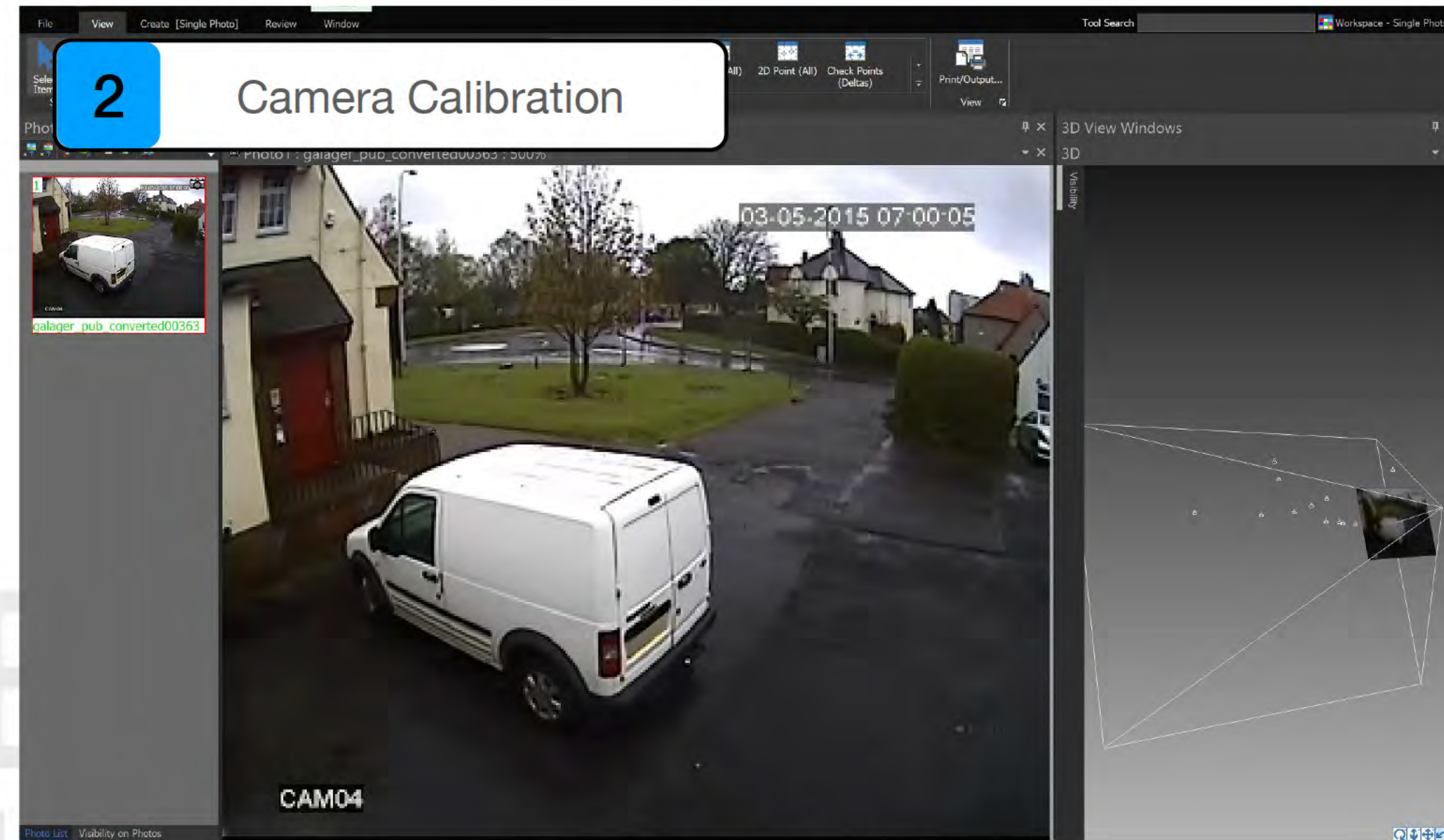
## ASSUMPTIONS / ACCURACY

- (a) ARLS GPS 1 - in exterior settings 5 metres accuracy
- (b) Can be significantly worse indoors or heavily built up areas
- (c) Linear transit between points - indicative only
- (d) Data not available for several vehicles in entirety
- (e) Data of several people not available later in the events



<https://www.gps.gov/systems/gps/performance/accuracy/#:~:text=Learn%20more,How%20accurate%20is%20GPS%20for%20speed%20measurement%3F,interval%2C%20with%2095%25%20probability.>

# Tracking Vehicles / People - Gallagher's

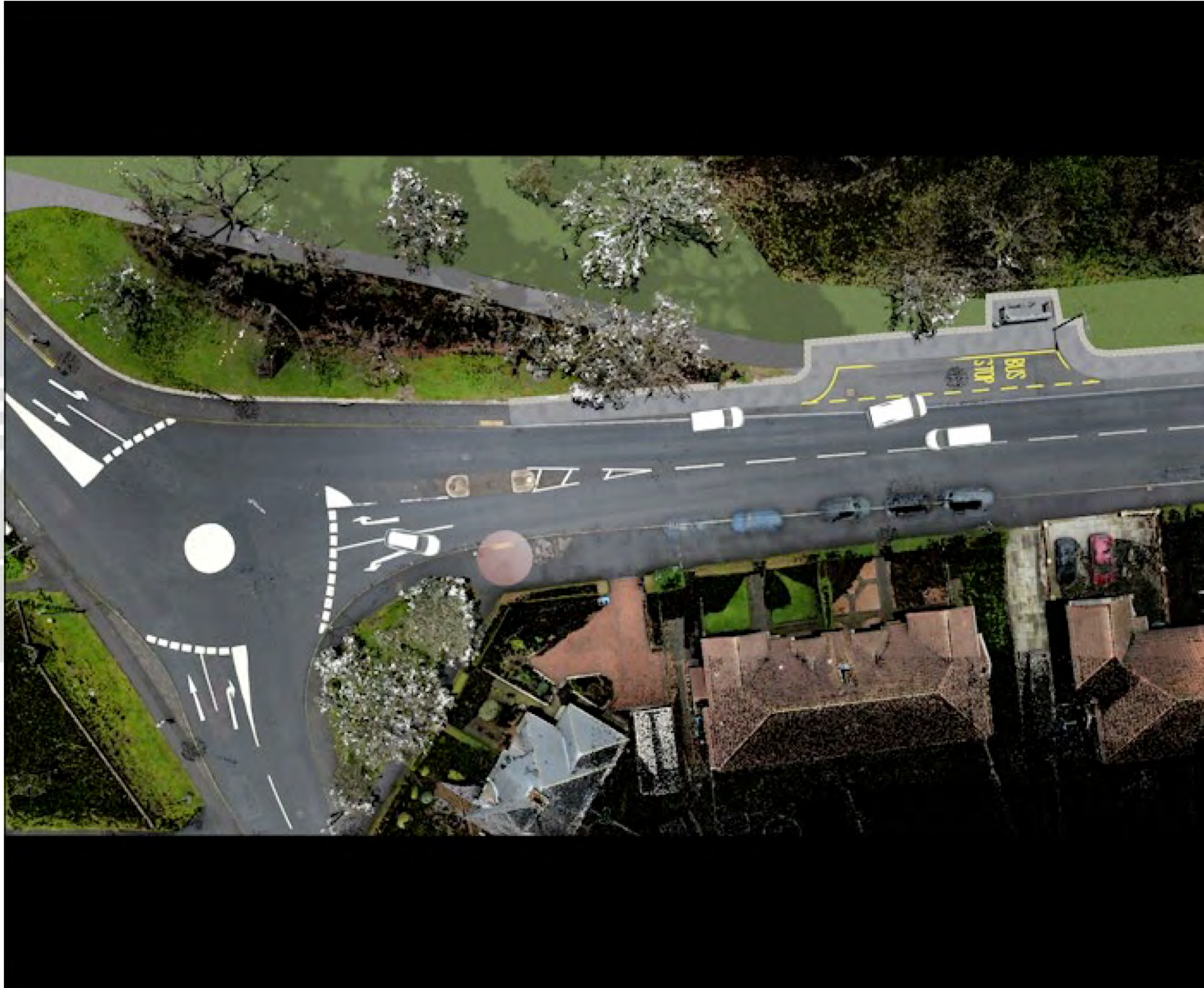




# Tracking Vehicles / People - Gallagher's

5

SHE  
BAY  
INQU

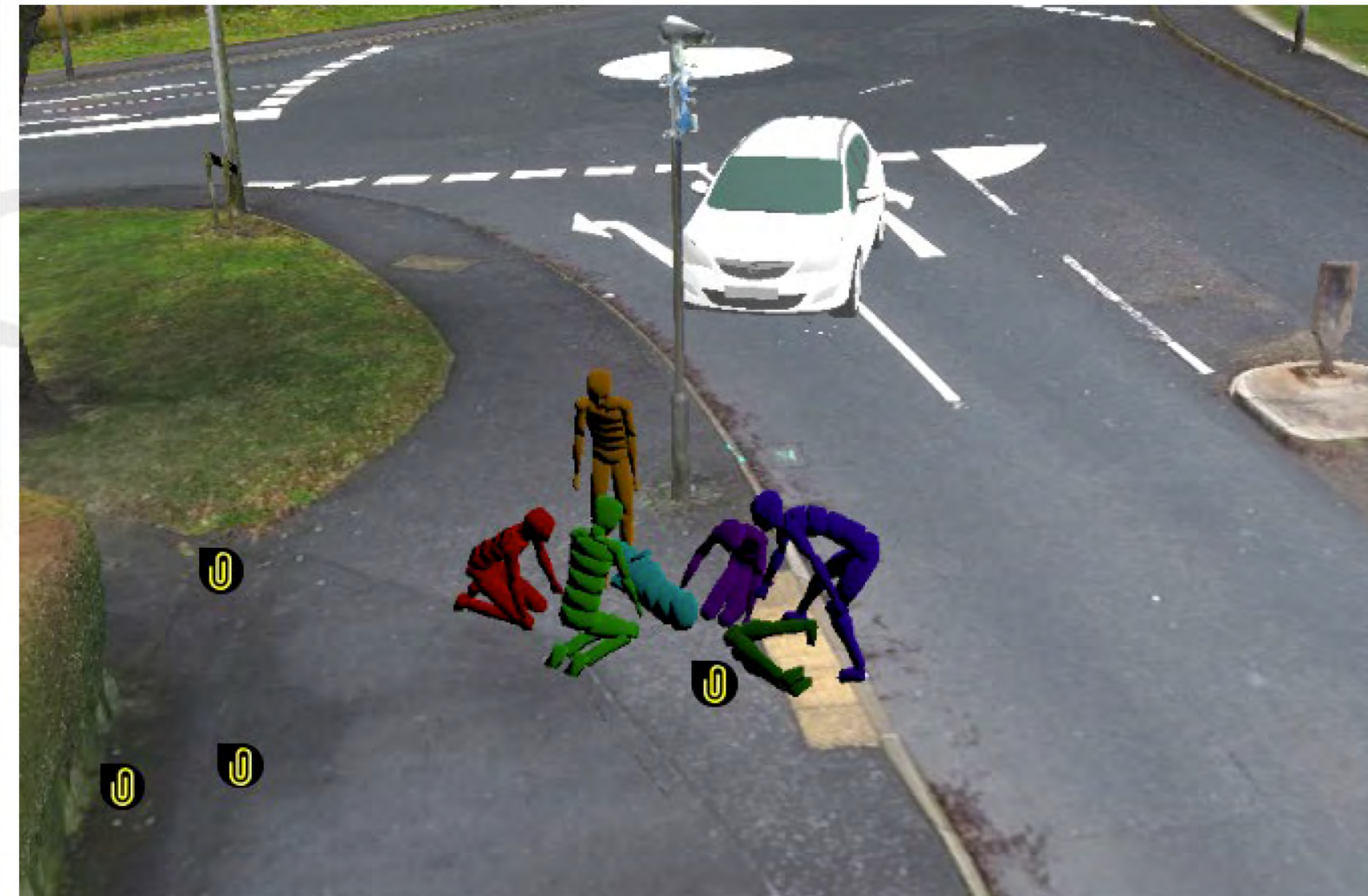


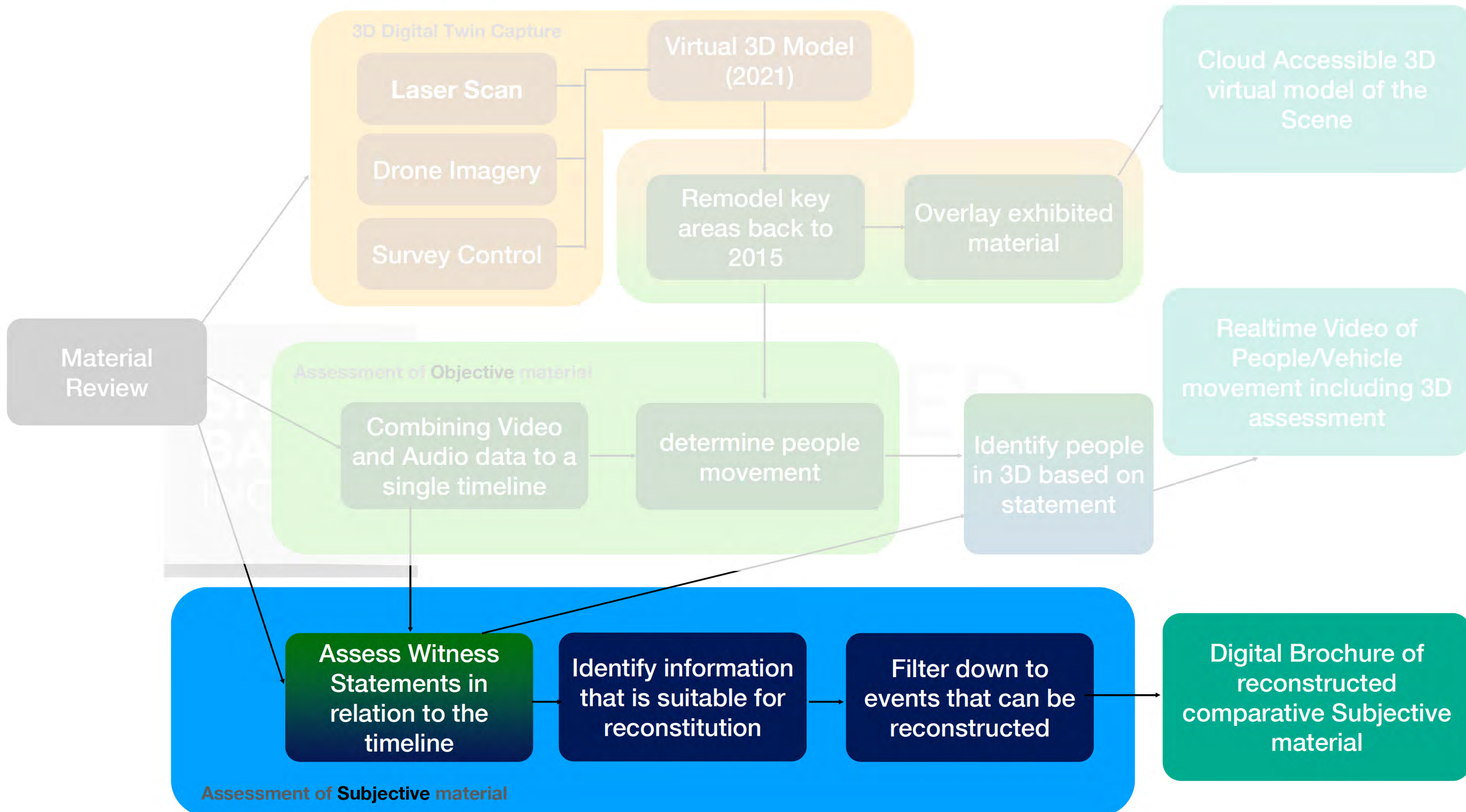
Real-Time Video

SHEKU  
BAYOH  
INQUIRY

RESTRICTED  
**DEMO**  
MATERIAL

# Tracking Vehicles / People - Snapchat

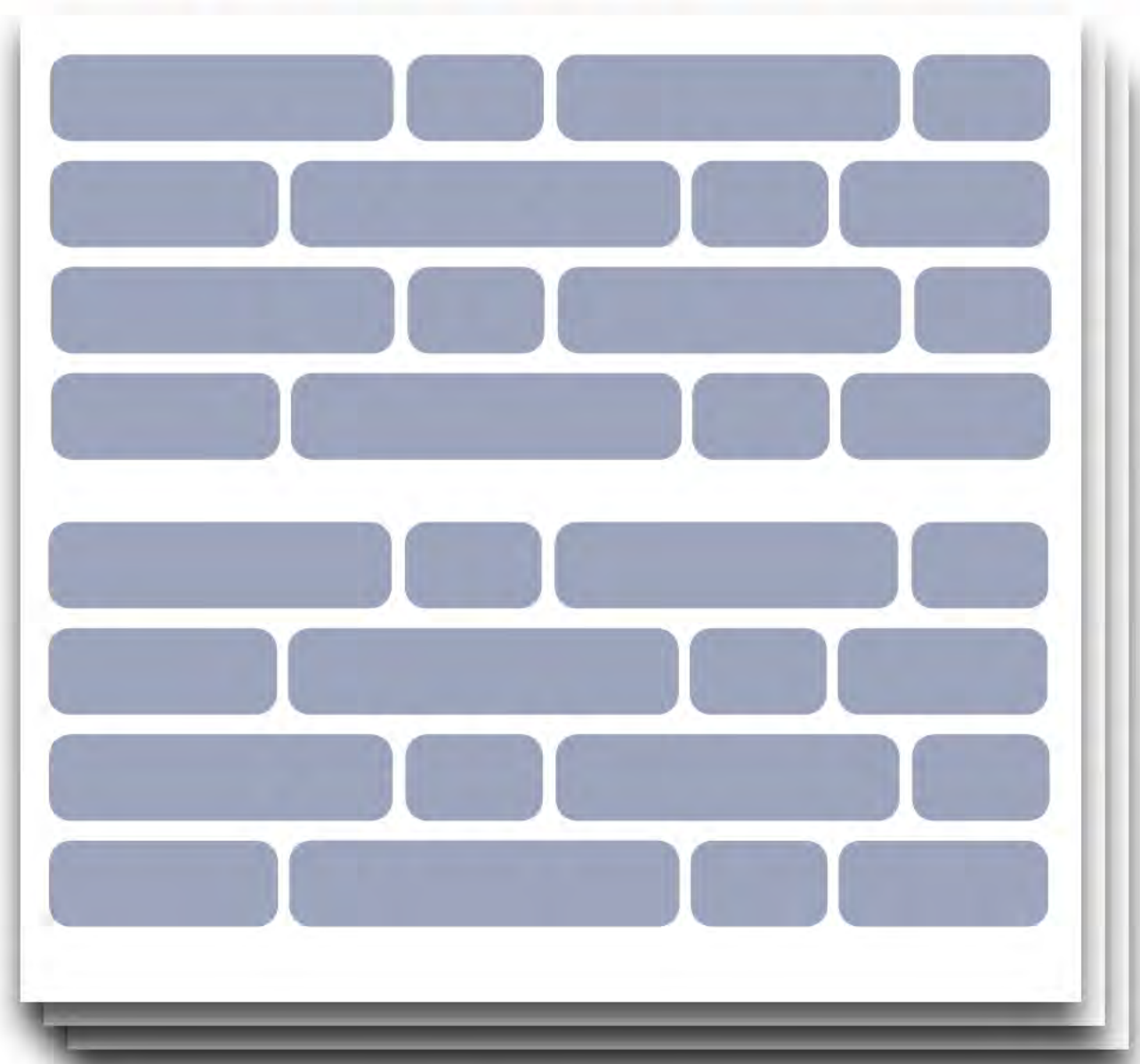




Subjective Material Assessment

# Information Identification

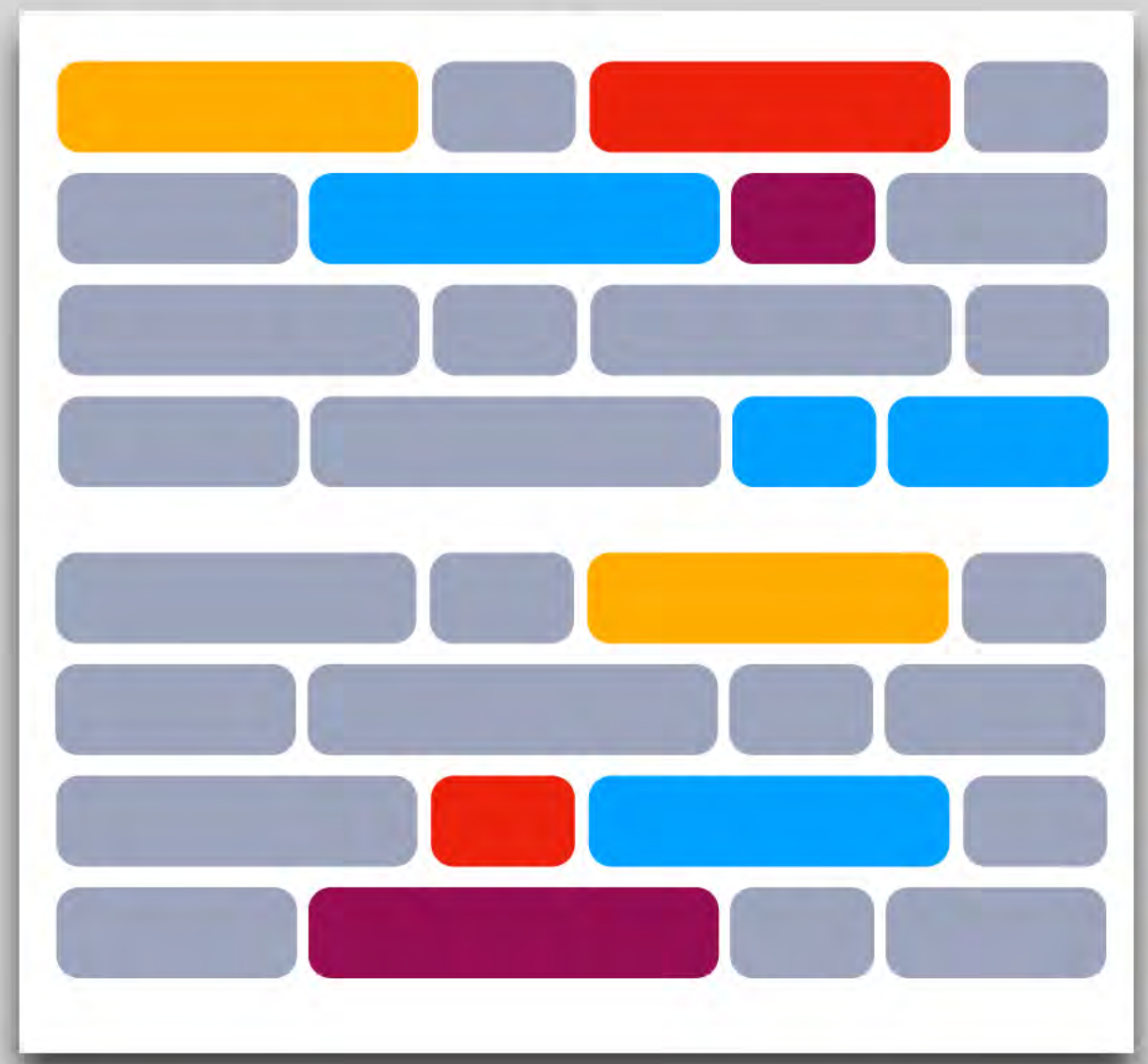
## Public & Police Statements



Eye Witness Statements



### Per Statement Analysis



#### Temporal

Information that relates to time or a timed event in the objective information available.

#### Spatial

Relates to location or relative position of events, persons or objects.

#### Person Identification

Information about persons that help in identifying participants.

#### Object Identification

Information about objects that are described.

# Assessment of Statements to Timeline

# Audio / Video Timeline

Temporal

REAL TIME  
7:28:25



101 CALLS

Audio & Video Timeline with reference to Real-Time Clock

| Real Time (From Video reconstruction) |               | Track | Caller ID (Airwave Transcription) | Event (Airwave Transcription by Inquiry Team)   | Description of visible events in Video   | Which Video Extract |
|---------------------------------------|---------------|-------|-----------------------------------|---|--|---------------------|
| Video Timings                         | Audio Timings |       |                                   |   |  |                     |
| 07.15.25                              |               |       |                                   |   | Person in light top and dark bottoms visible walking towards Gallaghers Pub on Hayfield Road   | Gallaghers CCTV     |
| 07.15.49                              |               |       |                                   |   | Person continues to walk towards the roundabout  | Gallaghers CCTV     |
| 07.15.50 - 07.15.55                   |               |       |                                   |   | Small, light coloured vehicle enters roundabout from North Hendry Road and passes person. Vehicle continues past roundabout on Hendry road going South. Appears to accelerate away from roundabout. Person changes direction and walks back to Hayfield Road   | Gallaghers CCTV     |
|                                       | 07:16:22      | 1     | Con 1                             | Control for ... four one Charlie  |  |                     |
| 07.16.28 - 07.16.42                   |               |       |                                   |   | Person has walked further up Hayfield Road but is still visible on CCTV. The person pauses and stands still for a couple of seconds and then progresses further up Hayfield Road and beyond the CCTV sight.  | Gallaghers CCTV     |
|                                       | 07:16:29      |       | P0691 PC Ashley Tomlinson         | Go ahead  |  |                     |
|                                       | 07:16:32      |       | Con 1                             | I need you to divert er to Hendry Road a disturbance on-going, male armed with a knife African looking male chasing someone may be carrying a knife described as big with muscles about six foot tall wearing a white t-shirt and dark coloured jeans there's another job coming in- about it, stand by |  |                     |
| 07.16.48 - 07.16.55                   |               |       |                                   |   | A grey or Silver car enters the CCTV FoV coming toward the roundabout on Hayfield Road. It crosses the roundabout going North on Hendry Road   | Gallaghers CCTV     |
| 07.16.56 - 07.17.02                   |               |       |                                   |   | A white car enters the CCTV FoV from the South on Hendry Road going North towards the roundabout. The vehicle turns right at the roundabout and enters Hayfield Road   | Gallaghers CCTV     |
|                                       | 07:16:59      |       | P0691 PC Ashley Tomlinson         | That's received Control is there other units that can assist us   |  |                     |
| 07.17.03 - 07.17.10                   |               |       |                                   |   | Two light coloured vehicles enter the CCTV FoV. First vehicle is travelling south on Hendry road and crosses roundabout to continue on Hendry Road. This vehicle appears to have something on the roof, Second vehicle is travelling North on Hendry Road and turns right at the roundabout to go up Hayfield Road. This is a smaller car. | Gallaghers CCTV     |
|                                       | 07:17:04      |       | Con 1                             | Yeah [inaudible] that's another grade one call coming in for the Victoria Road Kirkcaldy, male armed with a knife, male in possession of a large knife, a black male wearing white t-shirt and jacket walking along the street with a large knife in his right hand about a nine inch blade             |  |                     |
| 07.17.10 - 07.17.11                   |               |       |                                   |   | Dark coloured vehicle enters roundabout from North Hendry Road and crosses it to go South on Hendry Road.  | Gallaghers CCTV     |
| 07.17.11 - 07.17.16                   |               |       |                                   |   | Dark Coloured vehicle enters roundabout from North Hendry Road and goes left up Hayfield Road eventually leaving FoV.  | Gallaghers CCTV     |
|                                       | 07:17:23      |       | P0349 A/PS Scott Maxwell          | Control from four one one, I want all units to attend that, bearing in mind officer safety, is there an A-R-V and a dog as well please  |  |                     |
| 07.17.26 - 07.17.34                   |               |       |                                   |   | Light coloured small van enters CCTV FoV on Hayfield Road going towards roundabout. Turns left to go South on Hendry Road.   | Gallaghers CCTV     |
|                                       | 07:17:36      |       | P0694 PC Alan Paton               | Papa control from four one alpha  |  |                     |

Public Statements  
- Video Events

Police Statements  
- Airwave Events

# Assessment of Statements to Timeline

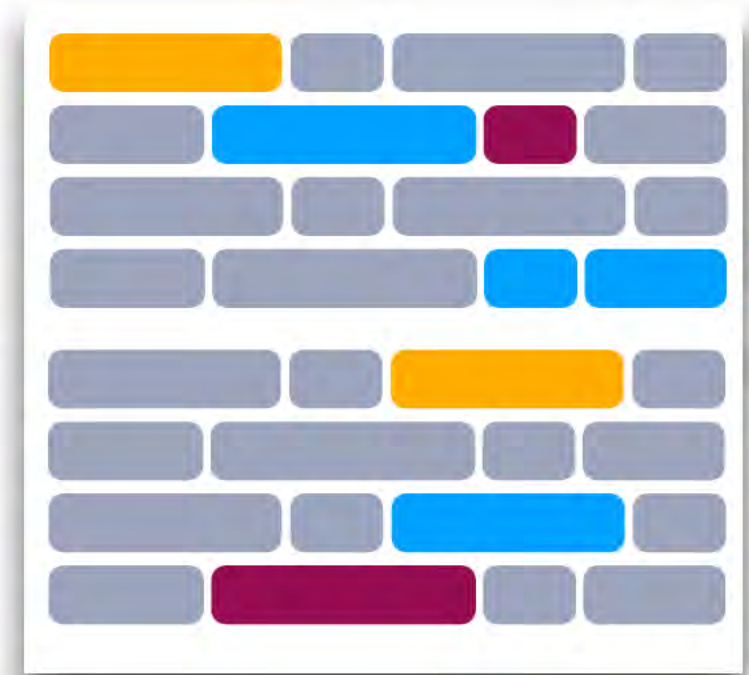
# Audio / Video Timeline

## Stage 1: Temporal Analysis

| Date     | Time     | Description |
|----------|----------|-------------|
| 07/16/18 | 07:16:00 | ...         |
| 07/16/18 | 07:16:05 | ...         |
| 07/16/18 | 07:16:10 | ...         |
| 07/16/18 | 07:16:15 | ...         |
| 07/16/18 | 07:16:20 | ...         |
| 07/16/18 | 07:16:25 | ...         |
| 07/16/18 | 07:16:30 | ...         |
| 07/16/18 | 07:16:35 | ...         |
| 07/16/18 | 07:16:40 | ...         |
| 07/16/18 | 07:16:45 | ...         |
| 07/16/18 | 07:16:50 | ...         |
| 07/16/18 | 07:16:55 | ...         |
| 07/16/18 | 07:17:00 | ...         |
| 07/16/18 | 07:17:05 | ...         |
| 07/16/18 | 07:17:10 | ...         |
| 07/16/18 | 07:17:15 | ...         |
| 07/16/18 | 07:17:20 | ...         |
| 07/16/18 | 07:17:25 | ...         |
| 07/16/18 | 07:17:30 | ...         |
| 07/16/18 | 07:17:35 | ...         |
| 07/16/18 | 07:17:40 | ...         |
| 07/16/18 | 07:17:45 | ...         |
| 07/16/18 | 07:17:50 | ...         |
| 07/16/18 | 07:17:55 | ...         |
| 07/16/18 | 07:18:00 | ...         |



## Stage 2: Further Information Identification

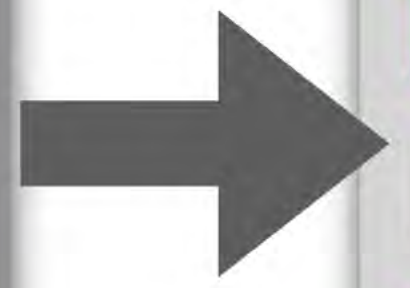


## Stage 3: Filtering

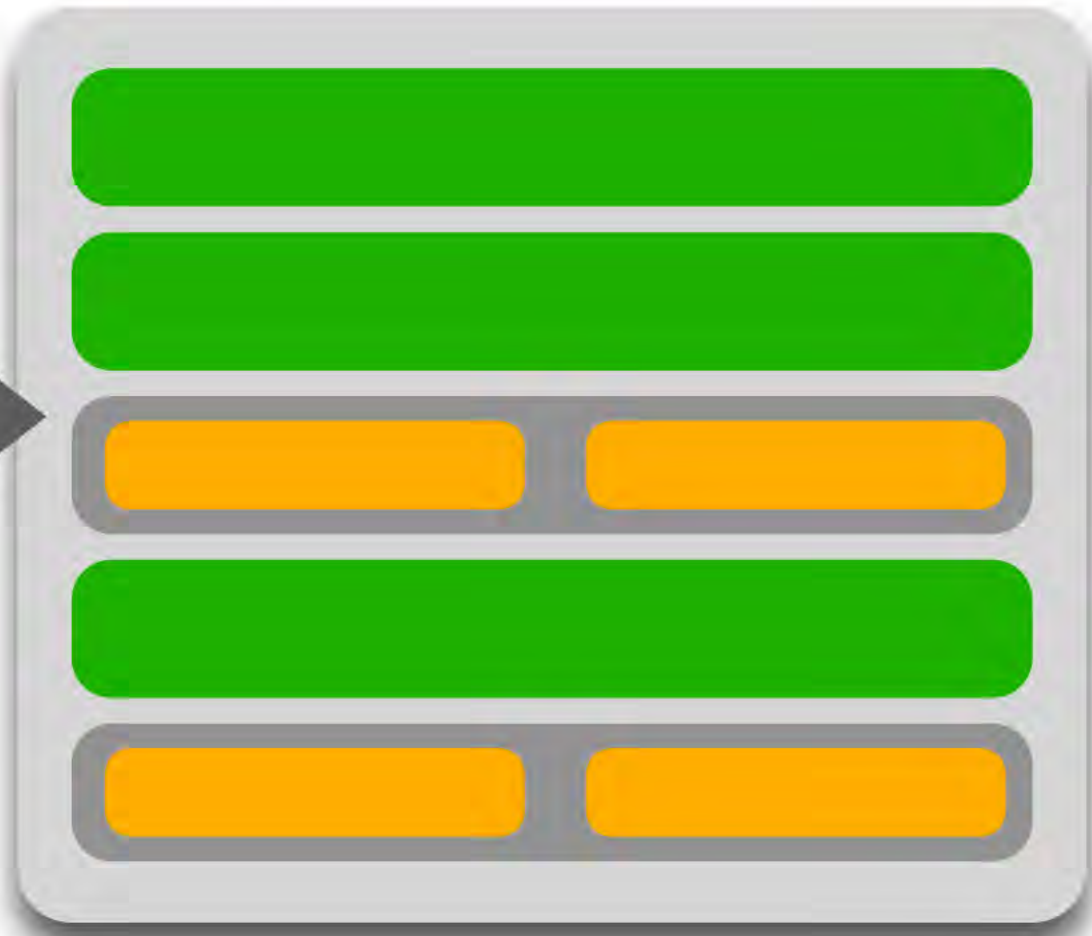
Filtered list of events to reconstruct

**Of interest to Inquiry**

**Areas of Dispute vs Agreement**



## Stage 4: Versioning & Reconstruction

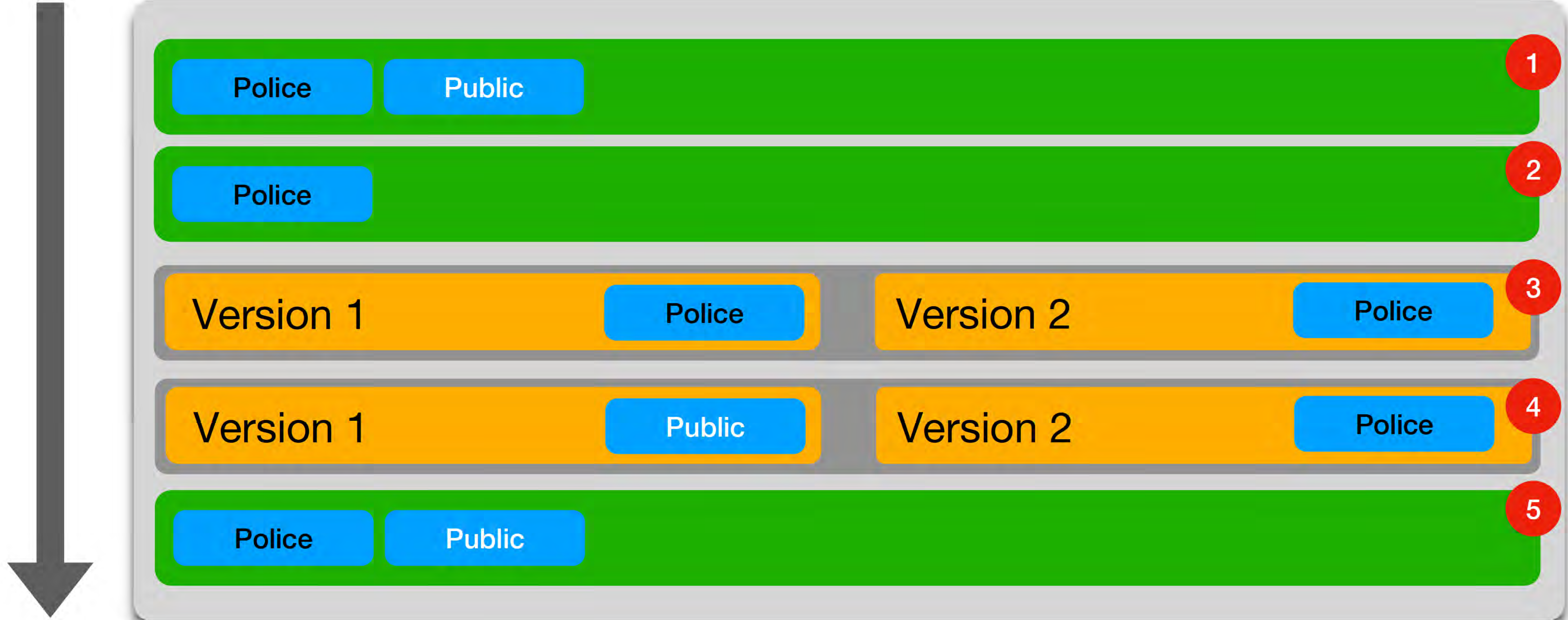


# Reconstruction Versions



Real-Time

Events





# Further Evidence



## Alleged Stomp Interactive 3D Scene

- Witness can direct placement of figures within scene
- Any viewpoint can be assessed

# Further Evidence

## Restraint Positions Stills of 3D Scene

- Multiple View Points
- Location of Mr Bayoh to be represented
- Distances will be shown to aid assessment
  - Witness can mark positions and other information on image





REAL TIME  
7:13:49

101 CALLS

999 CALLS

AIRWAVE

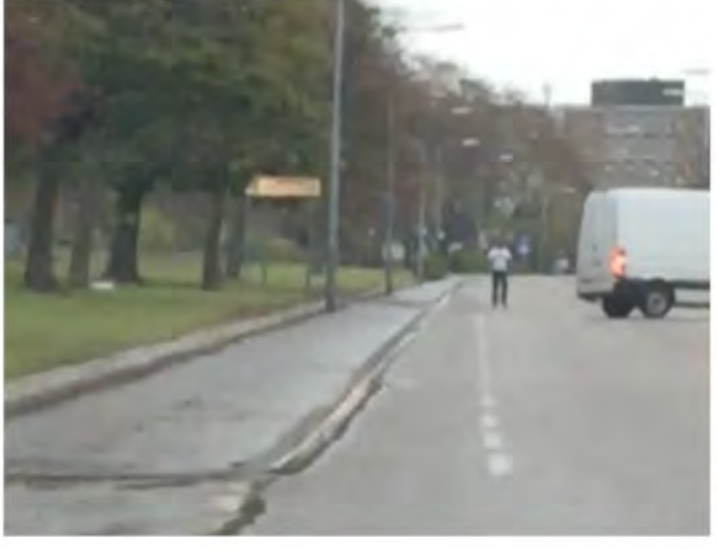
PIRC-01287 - Gallagher's CCTV  
Front View



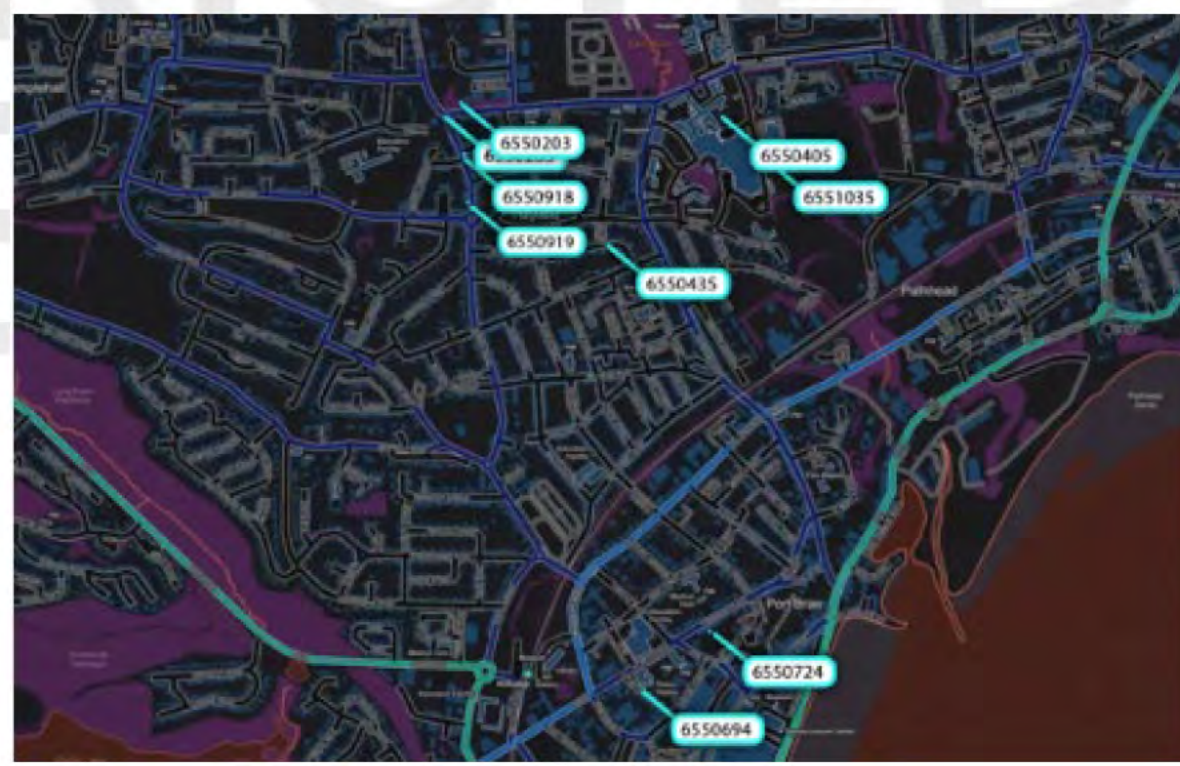
PIRC-01293 - Dashcam footage



PIRC-01289 - Robson Kolberg's iPhone



PIRC-01285 - Van driven by witness Grey



| Real Time (from Video Reconstruction) | Track | Color ID (Arrest Transcription) | Event (Arrest Transcription by Inquiry Team)   | Description of visible events in Video   | Which Video Extract |
|---------------------------------------|-------|---------------------------------|--|--|---------------------|
| 07:15:25                              |       |                                 |  | Person in light top and dark bottoms walks walking towards Gallagher's Pub on Hayfield Road  | Gallagher's CCTV    |
| 07:15:49                              |       |                                 |  | Person continues to walk towards the roundabout  | Gallagher's CCTV    |
| 07:15:50 - 07:15:55                   |       |                                 |  | Small, light coloured vehicle enters roundabout from North Hendry Road and passes person. Vehicle continues past roundabout on Hendry road going South. Appears to accelerate away from roundabout. Person changes direction and walks back to Hayfield Road   | Gallagher's CCTV    |
| 07:16:22 - 07:16:42                   | 1     | Can 1                           | Control for ... four one Charlie   | Person has walked further up Hayfield Road but is still visible on CCTV. The person pauses and stands still for a couple of seconds and then progresses further up Hayfield Road and beyond the CCTV light.  | Gallagher's CCTV    |
| 07:16:29                              |       | P0861 PC Ashley Tomlinson       | Go ahead   | I need you to divert to in Hendry Road a disturbance on-going, male armed with a knife African looking male chasing someone may be carrying a knife described as big with muscles about six foot tall wearing a white t-shirt and dark coloured jeans there's another job coming in about 1, stand by                                      |                     |
| 07:16:32                              |       | Can 1                           |  |  |                     |
| 07:16:45 - 07:16:55                   |       |                                 |  | A grey or silver car enters the CCTV FoV coming toward the roundabout on Hayfield Road. It crosses the roundabout going north on Hendry Road   | Gallagher's CCTV    |
| 07:16:56 - 07:17:02                   |       |                                 |  | A white car enters the CCTV FoV from the South on Hendry Road going north towards the roundabout. The vehicle turns right at the roundabout and enters Hayfield Road   | Gallagher's CCTV    |
| 07:16:59                              |       | P0861 PC Ashley Tomlinson       | That's received Control is there other units that can assist us.   |  |                     |
| 07:17:03 - 07:17:10                   |       |                                 |  | Two light coloured vehicles enter the CCTV FoV. First vehicle is travelling south on Hendry road and crosses roundabout to continue on Hendry Road. This vehicle appears to have something on the roof. Second vehicle is travelling north on Hendry Road and turns right at the roundabout to go up Hayfield Road. This is a smaller car. | Gallagher's CCTV    |
| 07:17:04                              |       | Can 1                           |  | Yeah (repeated) that's another grade one call coming in for the Hendry Road (repeated) male armed with a knife, male in possession of a large knife, a black male wearing white shirt and jacket walking along the street with a large knife in his right hand about a nine inch blade   |                     |
| 07:17:10 - 07:17:11                   |       |                                 |  | Dark coloured vehicle enters roundabout from North Hendry Road and crosses it to go South on Hendry Road.  | Gallagher's CCTV    |
| 07:17:11 - 07:17:16                   |       |                                 |  | Dark Coloured vehicle enters roundabout from North Hendry Road and goes up Hayfield Road eventually leaving FoV.   | Gallagher's CCTV    |
| 07:17:23                              |       | P0349 AFS Scott Maxwell         | Control from four one one, I want all units to attend that, leaving in next officer safety, is there an A.R.V and a dog as well please |  |                     |
| 07:17:26 - 07:17:34                   |       |                                 |  | Light coloured small van enters CCTV FoV on Hayfield Road going towards roundabout. Turns left to go South on Hendry Road.   | Gallagher's CCTV    |
| 07:17:36                              |       | P0864 PC Alan Paton             | Pipps control from four one alphas   |  |                     |



# Questions

Produced on behalf of the Sheku Bayoh Inquiry

