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CROWD DNA

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Report on Crowd Observatories

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Acronyms and Abbreviations

CDI	Crowd Dynamics International Limited
EC	European Commission
EMT	Executive Management team
FZJ	Forschungszentrum Julich Gmbh
GA	Grant Agreement
INRIA	Institut National De Recherche En Informatique Et Automatique
KPIs	Key Performance Indicators
ONH	Onhys
PO	Project Officer
UL	University of Leeds
ULM	Universität Ulm
URJC	Universidad Rey Juan Carlos
WP	Work-package

Executive Summary

This report focuses on the first set of observatories for CrowdDNA, looking specifically at the movement of people in an environment where the movement is uninhibited by controlled experiments. The intention is to create a data set for predicting crowd movement which once applied will enhance crowd safety. Through the identification of a range of event types through categorisation, a target list if observatories were contacted. Due to the annual nature of festival season, the focus was placed on pursuing festival observatories to maximise the number of festival seasons for observation throughout the duration of the CrowdDNA project. A systematic approach was taken to secure the observatories.

Scenarios and types of data to be captured were specified for each observatory type prior to attending, with specific ones being relevant to the festivals. This helped to inform what equipment would be required for data capture and the methodology as to how to capture it. The chosen approach was a combination of photo, video, body motion, Xsens suits, IoT tracking, mobile phone tracking and camera counters. The data capture methodology posed some production considerations and presented the requirement for a common framework to ensure GDPR compliance, as well as legal and ethical considerations.

The installed observatories took place between the 17th June and 20th August 2022, with one festival in France (Hellfest) and three in the UK (Tramlines, Bloodstock and ArcTanGent), all with varying capacities and curation. For each observatory, a detailed account of the data capture process is documented within this report, including maps, photos, and video file references. Observations made on site at each of the festivals has facilitated a feedback report to the owners and operators based on findings (issued separately to this report) but included in bullet point form within this report.

The data captured at each of the observatories may under-go further analysis than what is included in this report to generate algorithms for predicting crowd movement and in turn, increase crowd safety. Learnings from participating in the data capture exercises at observatories can be applied to all observatories moving forward and if required, more extensive data capture can take place at festivals in the 2023 season.

Photo credit: Joseph Singh Snaprockandpop © 2022 **NOT FOR PUBLICATION**

1. Introduction

1.1. Purpose of Observatories

The purpose of the observatories is to capture data of people movement in an environment where the movement is free and uninhibited by the control of a laboratory experiment. The intention is to gather data on the instinctive way in which people move within crowded environments and use these observations to predict crowd movement.

1.2. Goals of Observatories

- Create a data set of people movement within a range of crowded environments.
- Map the movement of people within a crowded environment and determine algorithms from the mapped movement.
- Use the algorithms to predict crowd movement, compare the predictions against the data to determine the accuracy of the algorithm.
- Make observations between data sets for similarities in crowd movement across observatories.
- Create an open-source data set for crowd management companies, event planners, health and safety advisors (etc.) to be able to reference.
- Increase crowd safety.

2. Observatories Strategy

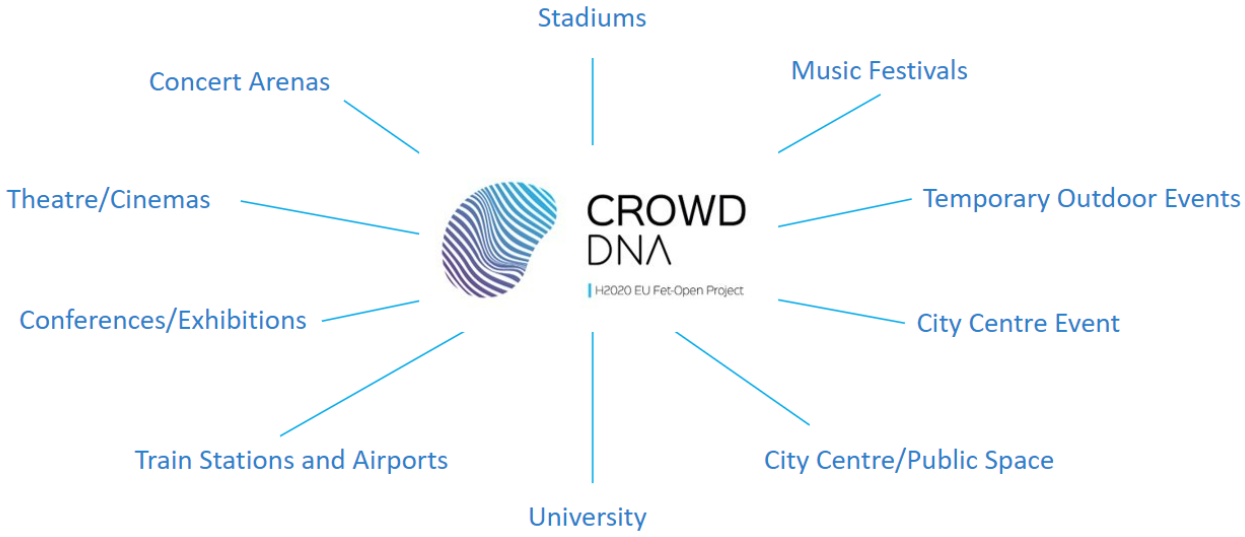
This section outlines the approach taken in identifying the types of events and venues that should be considered as part of the observatories study.

2.1. Range of Observatories

A process of identification of suitable event types has been conducted to categorise and appropriately quantify each typology and its possible size, scale, and the types of crowding conditions that are likely to be seen at each. It is crucial that a suitable profile of event types covering a broad range of events across the events industry is collated, so that the maximum number of different crowding behaviours can be assessed.

Identification of the different event typologies has taken place in coordination with other project partners, and these are presented in the figure below.

Figure 2.1 - Event Types



The taxonomy of each of typologies identified has been detailed, considering the possible size and scale, anticipated level of crowding, and the behaviours that could be seen at each event. This task has helped refine the profile of typologies and scope the range of behaviours which need to be studied. Table 2.1 below shows a taxonomy of event types for CrowdDNA observatories.

Table 2.1 - Taxonomy of Event Types

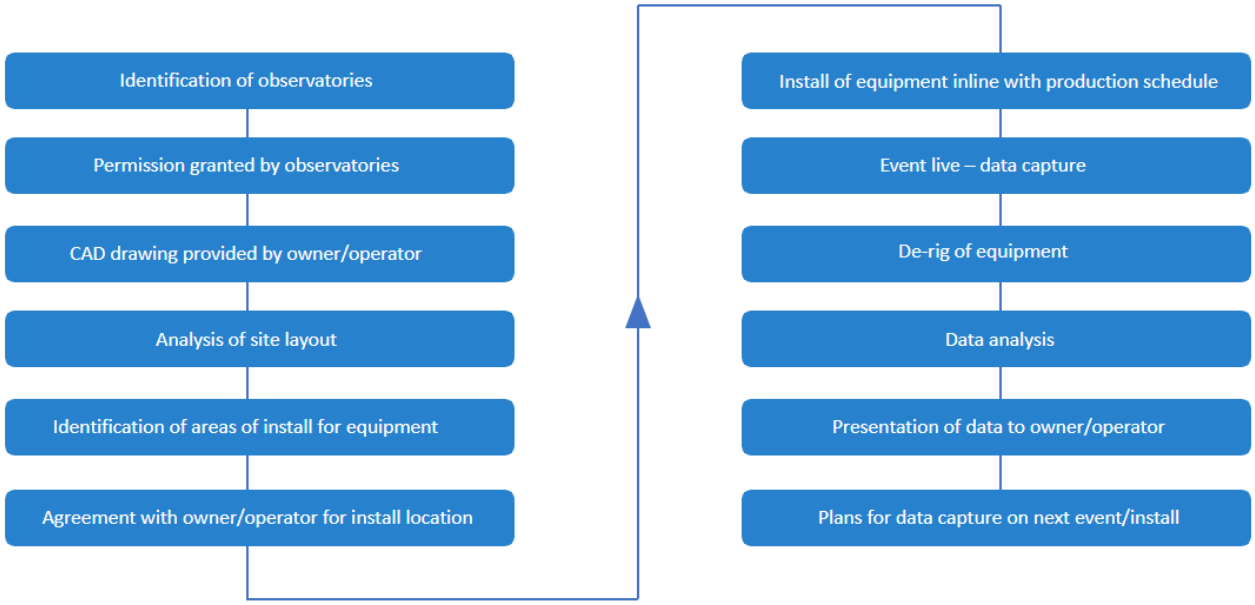
Category Number	Category Name	Examples	Size	Capacity	Density	Behaviour
1	Stadium	Stade De France, Wembley	very large building with outer concourses	20,000-100,000	high	one identity happy to be at high density, move together, hooliganism
2	Concert Arena	O2 Arena, Manchester Arena	large building with small outer spaces	5,000-20,000	medium/high	happy to be at high density, groups move or sit together

3	Theatre/Cinema	Bataclan, Opera House	small/medium building	1,000-3,000	low	seated crowd, slow moving, entry queues
4	Music Festival	Glastonbury, Tomorrowland	wide area with concentrated stages	10,000-100,000	high	standing crowds, high density, one identity
5	Temporary Outdoor Event/Fair	Winter Wonderland, Motor Show, Air Show	wide/small area with concentrated kiosks	100-5,000	medium/high	standing crowds, medium density
6	Conference-Exhibition	EXPO, EXCEL London, Palais des Festivals	large area with concentrated kiosks	1,000-5,000	low	standing crowds, low density
7	Train Station	London Euston	small area with street furniture	200-2,000	medium	standing crowds, medium density
8	Airport	Heathrow, Charles de Gaulle	medium size area with inner concourses	1,000-5,000	low	standing crowds, low density
9	City Centre/public space	Shopping street	medium size area with street furniture	100-1,000	low/medium	standing crowds, low/medium density
10	City centre event	Christmas Market/Local Festivals/New year's Eve	narrow area with street furniture	1,000-200,000	medium/high	standing crowds, low/medium density
11	University	Campus site or busy student areas	large campus/city centre student area	100-1,000	low/medium	student groups moving together, busy before/after lectures or in buildings
12	Night-time Economy Venues	Mayfield Depot FABRIC	Warehouse/ Old train station	10,000	medium/high	Standing crowds, busy key areas and plenty of crowd movement
13	Theme Park/Attractions	Thorpe Park, Disneyland Paris	Park area with indoor and outdoor entertainment and rides	Up to 55,000	medium/high	Moving crowds, queues, congested areas

2.2. Approach to setting up observatories

To select and set up effective and robust observatories at related events, several steps must be considered. This process has been identified and is presented in the flowchart below.

Figure 2.2 - Approach Flowchart



To allow for observatories to be set up and report in a timely manner, the following key milestones have been defined:

- 2021-22 – Scoping of potential observatories
    - Identify and approach venues
    - Agree dates and observation set-up
- 2022 – Festivals in summer
    - Conduct initial observations
    - Help identify data gathering requirements and issues faced
- 2022-2023 – Alternative types of venues
    - Conduct second round of observations across different venue types
    - Consider initial observations lessons learnt
- 2023 – Refine and repeat festival data gathering

2.3. Number of Each Category Targeted

In order to provide a reliable sample of events, considering the range of different sizes and event conditions, a number of each event/venue type will need to be targeted. For the purposes of this study an appropriate number of events which allows a robust analysis, is in the order of 4 to 5 events under each category.

2.4. Potential Observatories Contacted

Following the approach outlined in this section, a number of appropriate events/venues have been contacted. This list of events/venues is a 'living list' and will be updated as new events are approached and confirmed.

Table 2.2 - Events/Venues Contacted

Venue Category	Event/Venue	Location	Situation
Stadium	-	-	-
Concert Arena	AO Arena	Manchester, UK	Awaiting Response
	NEC	Birmingham, UK	Awaiting Response
	O2 Arena	London, UK	Awaiting Response
	02 Academy Brixton	London, UK	Awaiting Response
Theatre/Cinema	Tramlines	Sheffield, UK	Confirmed
	Hellfest	Clisson, France	Confirmed
Music Festival	ArcTanGent	Bristol, UK	Confirmed Attended August 2022
	Bloodstock	Burton-upon-Trent, UK	Confirmed Attended August 2022
	Damnation	Manchester	Confirmed Attending Nov 2022
	FOCUS Wales	Wrexham	Agreed to participate
	NASS	Somerset, UK	Confirmed but cancelled due to COVID
	Tramlines	Sheffield, UK	Confirmed Attended July 2022
Temporary Outdoor Event/Fair	Winter Wonderland	London, UK	In conversation for Nov 2022 – Jan 2023
	-	-	-
Train Station	-	-	-
Airport	Heathrow Airport	London, UK	Awaiting Response
	Gatwick Airport	London, UK	Awaiting Response
	Manchester Airport	Manchester, UK	Awaiting Response
	Stansted Airport	London UK	Awaiting Response
	East Midlands Airport	Derby, UK	Awaiting Response

City Centre/public space	-	-	-
City centre event	-	-	-
Night-time Economy Venues	Printworks	London, UK	Awaiting Response
	The Drumshed	London, UK	Confirmed, not attended due to permanent venue closure.
	Mayfield Depot	Manchester, UK	Confirmed
	Magazine London	London, UK	Awaiting Response
	Broadwick Live	Various, UK	Awaiting Response
	Evolution	London, UK	Awaiting Response
Theme Park/Attractions	Alton Towers	Stoke-on-Trent, UK	Awaiting Response
	Thorpe Park	London, UK	Awaiting Response
	Legoland	Windsor, UK	Awaiting Response
	Chessington World of Adventures	London, UK	Awaiting Response
	Dreamland	Margate, UK	Awaiting Response

3. Data Gathering

This section identifies the data gathering requirements and techniques needed to effectively capture and quantify crowd flow conditions and specific behaviours seen in the crowd observatories.

3.1. Scenarios/Use Cases to be Observed

Across the observatories, a variety of different crowd movement behaviours can be expected. Many of these are likely to be present across many or all event typologies, but present in different conditions and contexts. A variety of different data capture options will need to be considered to allow these behaviours to be quantified.

The main scenarios and use cases under which data capture will be required have been identified, considering all anticipated behaviours and aspects of people flow expected within the observatories. These are listed in the table below.

Table 3.1 - Scenarios/Use-cases for Data Capture

Scenario/Use Case	Data Capture
Large scale crowd movement	Mass movement of people through a large event, venue, public space, transportation hub
Queueing	Queue behaviour at various locations including ticket purchase, bars, merchandise, food concessions etc.
Main gateway of an entertainment environment	Ingress and egress of people through an entertainment environment
Stage (internal)	Dense crowd movements influenced by performed music within a structure
Stage (external)	Large scale dense crowd movements influenced by performed music outdoors
Person in crowd wearing body suit with pressure pads	1) Readings from the pressure suit 2) Movement of the individual wearing it through a crowd 3) The cascade effect of other people surrounding the individual
Walk-through experience	Cameras to track movement through a series of multiple rooms or spaces
Every-day use of transportation hubs	1) Movement throughout transportation hubs at various times of day 2) Bottle-neck areas such as security, ticket gates, passport control
Mass movement of people through entertainment venues	Movement of people through festivals and venues, capturing busiest times through key areas; gates, bars, stages, etc.
Mass movement of people through entertainment venues	Movement of people through festivals and venues, capturing busiest times through key areas; gates, bars, stages, etc.

The identified scenarios/use cases for data collection which are most relevant and need to be considered at each observatory type have been identified and are presented below.

Table 3.2 – Scenarios/Use Cases by Event

Event Typology	Scenario/Use Case
Stadium	Queueing Main gateway of an entertainment environment Stage (external) Person in crowd wearing body suit with pressure pads Mass movement of people through entertainment venues
Concert Arena	Queueing Main gateway of an entertainment environment Stage (external) Person in crowd wearing body suit with pressure pads Mass movement of people through entertainment venues
Theatre/Cinema	Queueing
Music Festival	Large scale crowd movement Queueing Main gateway of an entertainment environment Stage (internal) Stage (external) Person in crowd wearing body suit with pressure pads Mass movement of people through entertainment venues
Temporary Outdoor Event/Fair	Large scale crowd movement
Conference-Exhibition	Queueing Main gateway of an entertainment environment Walk-through experience
Train Station	Everyday use of transportation hubs
Airport	Everyday use of transportation hubs
City Centre/public space	Movement of people throughout the city centre and public spaces going about their everyday activity.
City centre event	A temporary city centre event, changes that creates to crowd movement throughout the city.
Night-time Economy Venues	Main gateway of an entertainment environment Stage (internal) Person in crowd wearing body suit with pressure pads

	Mass movement of people through entertainment venues
Theme Park/Attractions	Large scale crowd movement Queueing Main gateway of an entertainment environment

3.2. Types of Data to be Gathered

Each scenario/use case identified will require specific types of data to be gathered. The main types of such data have been detailed with input from across the research partners.

The primary data type will be video, recorded at static cameras, or on person, and may be recorded or live streamed. Other methods may also be utilised. These are listed in full below.

3.2.1. Video

High quality video recording required, ambition to use cameras with 4k resolution. This is needed to effectively monitor and scrutinise movement of individuals or groups in large, crowded spaces or low-light events.

For any video recorded, a video log should be produced summarising key details of each video recorded has been produced. This acts as a point of reference, allowing key video files to be easily identified for analysis, and is shown in the example below.

Figure 3.1 - Video Capture Log

Original Name	Video Name	Date	Time	Length	Location	Description	Observations
GH010005	Tramlines_Friday_Bag_Check_Gate1	22/07/2022	12:17	00:10:00	GATE 1	Capture taken at bag check at gate 1, taken as gates opened at midday on Friday	
GH010006	Tramlines_Fri_Ingress_Gate1_1	22/07/2022	12:30	00:00:55	GATE 1	Captures of crowds ingressing to the festival site at the beginning of the day, camera is positioned away from the Gate 1 entrance, towards the festival site	
GH010007	Tramlines_Fri_Ingress_Gate1_2	22/07/2022	12:31	00:06:40	GATE 1		
GH010008	Tramlines_Fri_Ingress_Gate1_3	22/07/2022	12:39	00:09:00	GATE 1		
GH010009	Tramlines_Fri_Adj_Pinchpoint_Afternoon_1	22/07/2022	14:05	00:11:47	Pinchpoint	Crowd movement between Arena 2/3 (Right) and Arena 1 (Left) - captured towards the end of Shed 7 performance on Main Stage. Camera postion is adjacent to the main pinchpoint	
GH020009	Tramlines_Fri_Adj_Pinchpoint_Afternoon_2	22/07/2022	14:16	00:11:47	Pinchpoint		

Hellfest Observatory used the following kit:

- 1 camera aca1300-60gc + focal len = 6 mm (for sensor format 2/3") HF6XA-5M ~58° HFoV
- 1 camera aca1300-60gc + focal len = 25 mm (for sensor format 2/3") HF25XA-5M ~15° HFoV
- Camera were fixed in height above the crowd using articulating arm and clamp. They were inaccessible during festival for security reasons (location was shared with pyrotechnical equipment)
- With GiGE interface, camera were fully operated through ethernet.
- Data captured on a PC, compressed, stored and transferred to a NAS drive.
- 20 fps (limited by network capacities)

Figure 3.2 – Camera acal

UK Festival Observatories used the following kit:

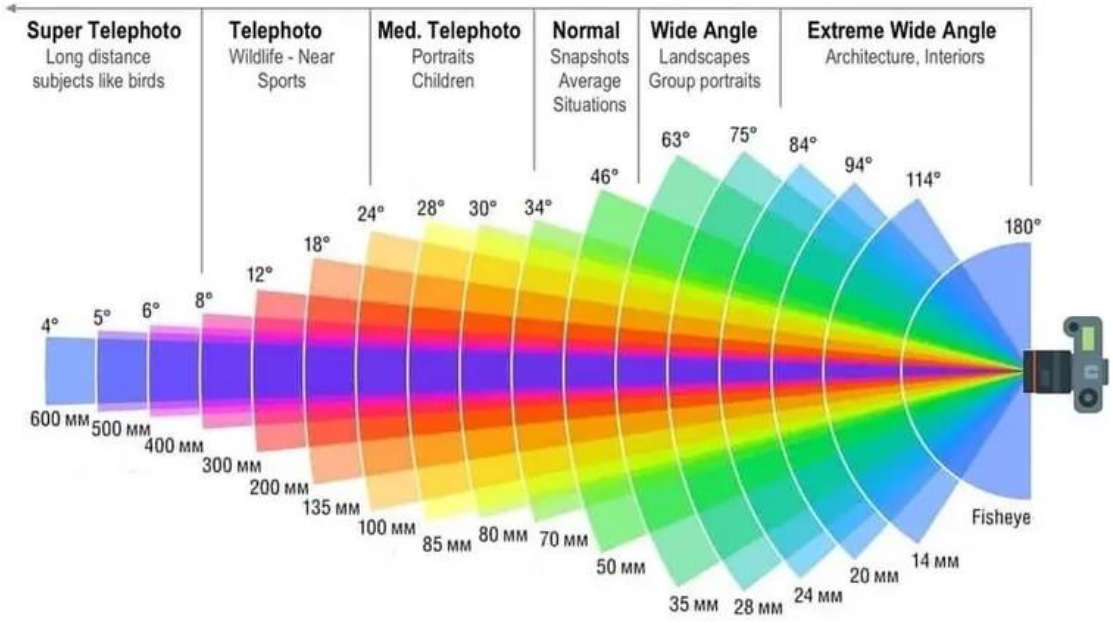
- GoPro Hero 8
- Fixed lens
- 30 fps at 1080p
- 12-megapixel sensor (4000 by 3000 pixels)
- Video stabilisation from HyperSmooth 2.0
- Data captured on SD card and backed up to hard-drive
- Multi-angle video content and single location content
- Fixed locations – on tripods
- Roaming – walk through of the site

Figure 3.3 – GoPro Hero 8

Other equipment considered for observatories:

- Wide angle/360-degree camera
- Thermal camera required for night-time? Does it provide useful data?
- Angle of cameras will change based on lens used (Figure 3.1)
    - Wide angle lens may only require 3 corner points and one centre point to capture the same area as a fixed lens in four corners and one in the centre
- Footage distortion likely to occur? Do we have capabilities to process this?
- Single camera footage vs multi angle for different purposes

Figure 3.4 – Type of lenses



3.2.2. Photos

Photos are to be taken to compliment other data capture and allow feedback to given to the observatories themselves:

- Smart phone photos of for orientation, general observations, and camera angles for video data capture. Roaming photos and fixed location photos.
- Stills taken from video footage
- Marketing photos provided by the observatory.

3.2.3. Body Motion

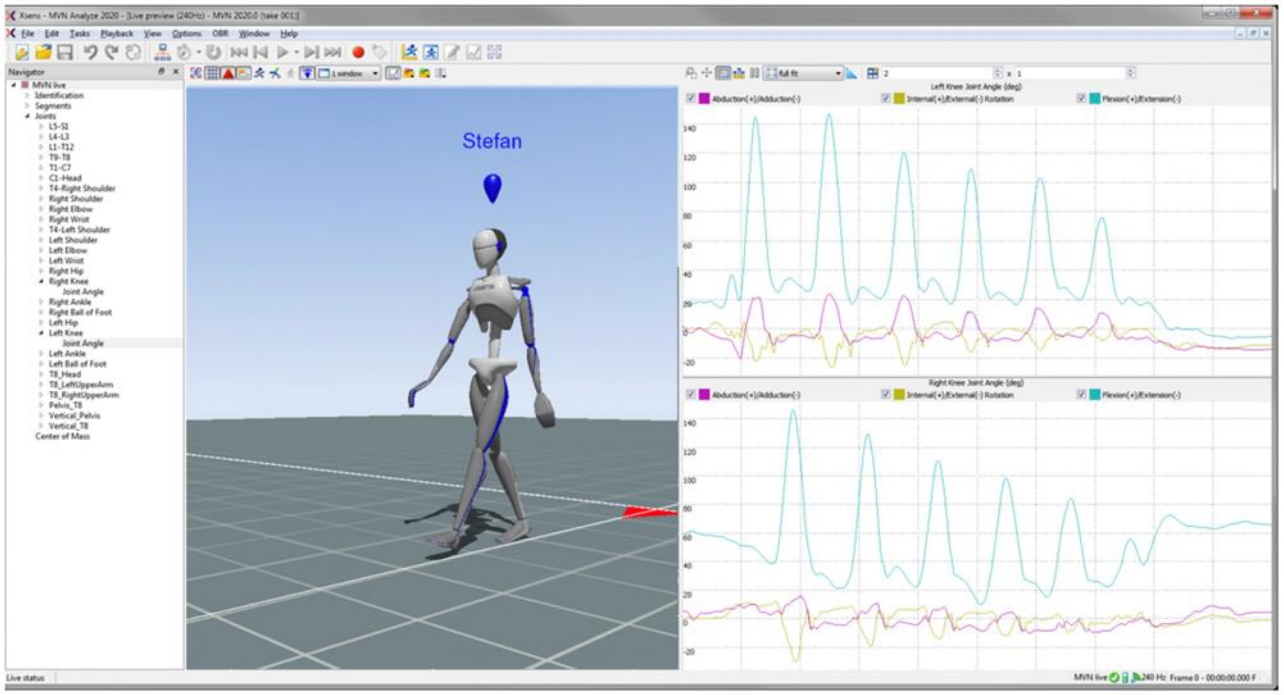
We use the 3D motion capturing (MoCap) system MVN Link by Xsens to track the full body motion of a person in the crowd (Schepers, Giuberti, & Bellusci, 2018). While optical MoCap Systems need a free line of sight between the tracking points on the body and a set of cameras, the Xsens MoCap system uses inertial measurement units (IMU) as sensors. These IMUs measure the acceleration, the angular rate and the magnetic field strength and a line of sight between the body and a camera is not necessary. Therefore, capturing of the full body motion is even possible in dense crowds.

Each MVN Link suit (as shown in Figure 3.) is equipped with 17 IMU sensors on predefined independently moving body segments. The measurement can be triggered manually, and the recorded data is stored locally on a device in the suit. Thus, the measurement is self-contained, and the data can be downloaded afterwards.

After performing a calibration procedure and taking detailed body dimension measurements, the MVN Analyse software then calculates the full body motion based on a biomechanical model from the measured data set (see example in Figure 3.). The processed data then includes the orientation, position, velocity, acceleration, angular velocity, and angular acceleration of each body segment as well as the angles of joints and the location of the centre of mass. The data can be exported either as xml-file or as biomechanical c3d-file.

Figure 3.5 –Xsens MVN Link Lycra suit (left) and Associated IMU Sensors (right) (Xsens, 2022)

Figure 3.6 – Example View of MVN Analyse Software Showing an Avatar Representing Biomechanical Data Recorded by Xsens Mocap &Sample Graphs of Data Captured (Xsens, 2022)



3.2.4. IoT Device Tracking

IoT tracking consists in detecting the presence of mobile devices (such as phones, smart watches, wireless earphones, etc.) near sensor terminals (Figure 3.) when their WiFi or Bluetooth systems are turned on (thereby emitting regular wireless signals). These signals contain identifying data (MAC address) that allows to follow the rough evolution of the position of the device over time.

This technology is thus adapted to a measurement of the flows of movements of a crowd, making it possible to approximate at the individual scale which is the path followed on a broad spatial and temporal scale. The tracking system we used was delivered by the INOCESS company in France (https://www.inocess.com/).
Let's note some particularities of this type of tracking, and of the one we used in crowd observatories:

- There is limited correspondence between devices and people. Only a proportion of the population has a mobile terminal with WiFi and/or Bluetooth enabled. It is also possible that the terminal switches on and off. On the other hand, a person may possess multiple such devices as well (e.g. phone and watch and earphones). Finally, note that a MAC address may change over time (e.g. around every fifteen minutes for Apple devices), making it impossible to track a device over a large period of time. The quantification of the flows is therefore subject to the estimation of the proportion of active terminals.
- The position estimation is coarse. In a basic way, the detection of a terminal makes it possible to know that it is close to a sensor terminal. The accuracy of the positioning is equivalent to the dimensions of the collection zone of a terminal, ranging from a few meters to a few dozen meters. More precise information requires the use of several sensors in the same area and a calibration procedure. We have only looked for a coarse positioning in the experiments related to CrowdDNA.
- The tracking of a terminal identified by its MAC address violates the RGPD laws protecting privacy. Indeed, it allows to potentially know the paths of an individual on large scales of time and space. However, it is easy to encrypt this information in an irreversible way, and to limit the tracking to small scales of space and time, not allowing to trace the identity of the wearer. This is further helped in a sense by the frequent MAC address changes of the devices, essentially subdividing paths into many sub paths which, from the point of view of the reconstruction system, may or may not be related. Thus, the technology we use: 1) encrypts the sensed MAC addresses directly at the source, on the sensor, to avoid storing clear MAC addresses, 2) is limited to tracking on the studied crowd observatory, and 3)

changes the MAC address encryption parameters regularly (once a day), on top of the devices' own MAC changing, to prevent cross-checking over several days, or over several locations if the device was used in another space frequented by the owner.

The many unknowns involved in this system make it such that no counting is possible, and precise tracking of individuals is not feasible either. The purpose of this technology is rather to determine the rough proportions of crowds which move between well distinct zones of a monitored area (such as the paths in green in Figure 3.8, where major trajectories could be found between a few different rooms and the entrance of a building). As such, if zones of specific interest can be identified, then it is possible to infer the preferred paths and travel times between them. In crowd observatories, this technology has been useful in trying to understand, even roughly, the flows around a specific observation point where other data collections methods were employed.

Figure 3.7 - Nextent eKo Bluetooth/WiFi Sensor (Image Courtesy of Inocess)

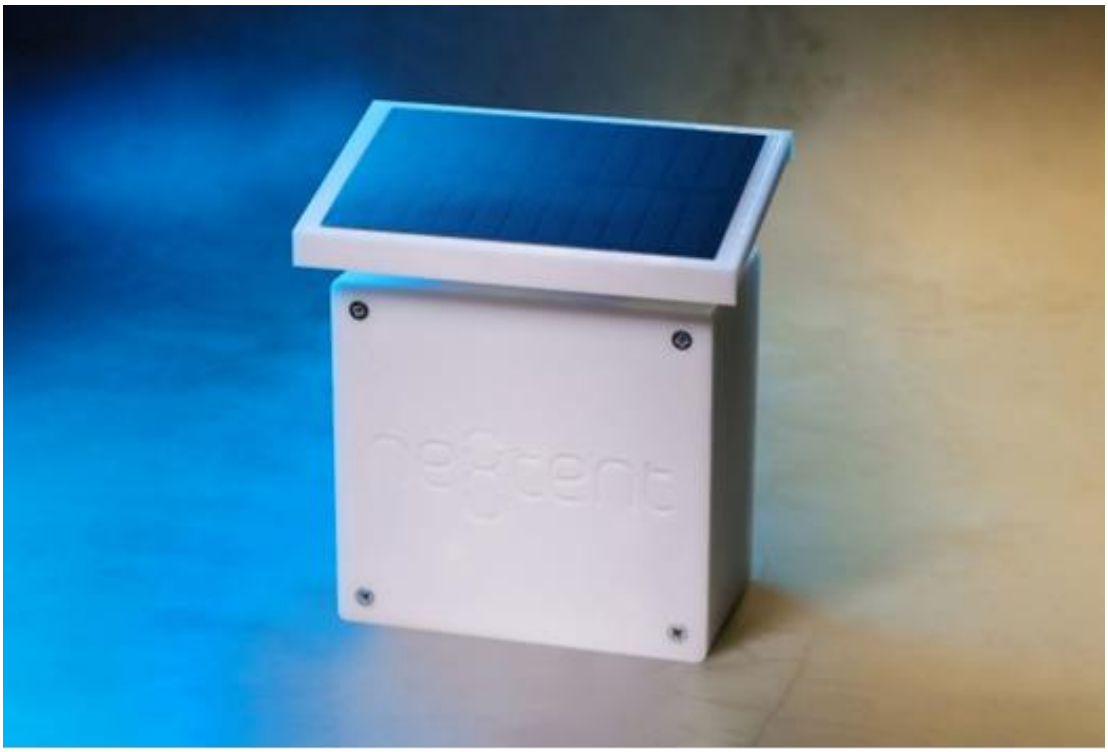
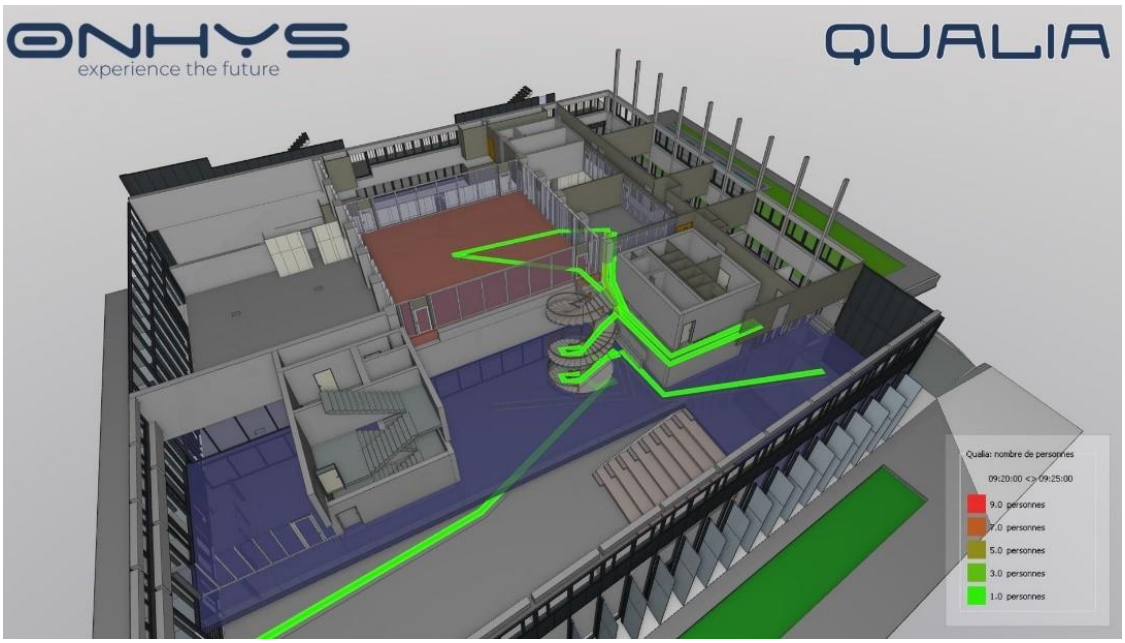


Figure 3.8 - Main Visitor Paths Reconstructed from IoT Tracking Data inside a Building



3.2.5. Mobile phone tracking

Cell phone tracking consists of detecting the presence of phones near sensor terminals that emit a regular signal when their Wifi or Bluetooth systems are turned on. This signal contains identifying data (MAC address) that allows to follow the evolution of the position of the device over time.

This technology is thus adapted to a measurement of the flows of movements of a crowd, making it possible to know at the individual scale which path is followed on a broad spatial and temporal scale. The tracking system we used was delivered by the INOCESS company in France (https://www.inocess.com/)

The particularities of this type of tracking, and of the one we used in crowd observatories:

- The tracking is partial: only a proportion of the population has a mobile terminal with Wifi and/or Bluetooth enabled. It is also possible that the terminal switches on and off. Finally note that MAC address may change over time, making impossible to track a device over a long timeframe. The quantification of the flows is therefore subject to the estimation of the proportion of average active terminal.
- The position estimation is coarse. In a basic way, the detection of a terminal makes it possible to know that it is close to a sensor terminal. The accuracy of the positioning is equivalent to the dimensions of the collection zone of a terminal, ranging from a few meters to a few dozen meters. More precise information requires the use of several sensors in the same area and a calibration procedure. We have only looked for a coarse positioning in the experiments related to CrowdDNA.
- The tracking of a terminal identified by its MAC address violates the RGPD laws protecting privacy. Indeed, it allows identification of the movements of an individual on large scales of time and space. However, it is easy to encrypt this information in an irreversible way, and to limit the tracking to small scales of space and time, preventing the identity of the wearer to be traced. Thus, the technology we use: 1) encrypts the sensed MAC addresses directly at the source, on the sensor, to avoid storing clear MAC addresses, 2) is limited to tracking on the studied crowd observatory, and 3) changes the MAC address encryption parameters regularly (once a day) to prevent cross-checking over several days, or over several locations if the device was used in another space frequented by the owner.

In crowd observatories, this technology has been useful in trying to understand, even roughly, the flows around a specific observation point.

3.2.6. Counting systems

Other types of data are available to get information on number of people in the space without directly recorded using sensors. Examples are:

- Redemption data from ticket company for ingress (does not include staff, crew and talent).
- Ticket gate data for permanent venues/transport hubs
- Daily attendance data as reported by the event/venue
- RFID data (e.g. purchases made on a card)

Other counting methods that can be used are:

- Camera counter sensors such as thermal kinetic sensors
- Video counters
- Beam Counters
- Thermal Counters

For scenario/use case and type of data a capture method has been proposed, as listed below. Limitation regarding each method have been identified.

Table 3.3 - Data Capture Method

Scenario	Data Capture	Methodology	Potential Limitations
Large scale crowd movement	Mass movement of people through a large event, venue, public space, transportation hub	1) Tethered drone footage 2) Live stream down to a laptop to store video content on a hard drive for data analysis	1) Expensive 2) Weather conditions
Queueing	Queue behaviour at various locations including ticket purchase, bars, merchandise, food concessions etc.	Fixed camera filming at busiest times	1) Weather conditions
Main gateway of an entertainment environment	Ingress and egress of people through an entertainment environment	Fixed camera(s) to capture queue movement, movement through the gate, and movement beyond the gate	1) Weather conditions 2) Exposure issues at night
Stage (internal)	Dense crowd movements influenced by performed music within a structure	1) Fixed camera taking aerial footage 2) Multi-angle cameras to give 360 coverage of the crowd	1) Weather conditions 2) Exposure issues at night
Stage (external)	Large scale dense crowd movements influenced by performed music outdoors	1) Fixed camera(s) taking footage 2) Angle of camera(s) will vary depending on stage design and access 3) Fixed camera positioned at Front of House	1) Exposure issues at night 2) Lighting effects and strobes make footage unusable
Person in crowd wearing body suit with pressure pads	1) Readings from the pressure suit 2) Movement of the individual wearing it through a crowd 3) The cascade effect of other people surrounding the individual	1) Focused area 2) Camera positions directly above the crowd. 3) Person wearing a body suit and a brightly coloured hat to help with visualisation when processing data.	1) Matching the pressure-pad data to the video content 2) Exposure due to lighting effects
Walk-through experience	Cameras to track movement through a series of multiple rooms or spaces	Cameras fixed to capture each room. Timestamps on footage so speed of movement through spaces can be calculated	Exhibition obstructs some viewpoints resulting in missing data
Every-day use of transportation hubs	1) Movement throughout transportation hubs at various times of day	Fixed cameras at key locations	1) Permission 2) Security considerations

	2) Bottle-neck areas such as security, ticket gates, passport control		3) No fly zone – drones cannot be used
Mass movement of people through entertainment venues	Movement of people through festivals and venues, capturing busiest times through key areas; gates, bars, stages, etc.	RFID chips in wristbands	1) Expensive 2) Data ownership 3) Wi-fi reliability for festivals
Mass movement of people through entertainment venues	Movement of people through festivals and venues, capturing busiest times through key areas; gates, bars, stages, etc.	Mobile phone tracking	1) GDPR compliance issues 2) Mobile phone signals on festival sites are often unreliable so may impact on the data

3.3. Production Considerations

Data collection on-site requires careful consideration of the provision of facilities and utilities which are crucial to the ability to effectively collect data at an event. These considerations are as follows:

- Site Wi-Fi
    - Partitioned Wi-Fi to avoid lag
    - 4G/5G Wi-Fi back-up solutions
    - Weather implications on Wi-Fi
    - No Wi-Fi at all
    - No 3G/4G/5G at all
- Power
    - Access to power
    - Recharging roaming equipment
    - Getting power to a fixed position
    - Necessary equipment/cables
    - Proximity of power: the requirement for a runner and/or mobile charging solution
    - Power outage due to generator failure
- Fixed Equipment
    - Integration with festival/observatories build schedule
    - Rigging and de-rigging of equipment
    - Tickets required for plant machine operation
    - Equipment inaccessible throughout event
    - Requires constant power
    - Data download required
- Access Requirements

    - Need suitable crew accreditation and necessary H&S training for install/de-rig of equipment
    - Media passes required for roaming footage capture
    - Camera operators required throughout the weekend
    - Privacy Policies updates
    - Signs displayed detailing participation in the project
- Footage Capture
    - Exposure – stage lighting affecting exposure (e.g. strobes)
    - Equipment failure
    - Data download failure
    - Damage to equipment (e.g., from extreme weather conditions)
    - Loss of SD cards/external HDDs
- Liability
    - Public Liability and Equipment Liability insurance.
    - Consideration as to where liability lies if subcontractors install kit.
    - Determine whether insurance is required for if data download fails.

4. Legal & Ethical Aspects

4.1. Common framework (GDPR)

The General Data Protection Regulation (GDPR) gives, over Europe, a general framework and a set of rules on privacy. GDPR has an impact on crowd observatories, since CrowdDNA aims at recording videos there, that may contain identifiable faces, for instance.

The key principles at the heart of the law should inform every step of a privacy management in crowd observatories. We review the 7 key principles of GDPR below to explain we adjusted personal data processing to satisfy this legal framework:

4.1.1. Lawfulness, fairness and transparency

This principle implies, for example, that any processing of personal data must be subject to the prior consent of those concerned to allow the use of their personal data. In the context of a crowd observatory, this is generally not possible, because the population is too large to allow the collection of such consents.

To satisfy this principle, we use certain national clauses that allow us to refrain from collecting personal consent:

- In view of the nature of the data collected, in our case videos of a crowd where individuals are difficult to recognize anyway, and the first data processing step is to filter out video sequences where people would be easily recognized.
- In view of the purpose of the data collection, which is to allow public research that benefits the security of mass events
- On the condition of maximizing access to information that informs about the data collection on site, through visible displays for example.

4.1.2. Purpose limitation

The purpose of the data collection in crowd observatories is to allow research on crowd behaviors and the development of technologies to assist mass event organizers in improving safety. Data should never be utilized out of this purpose. The purpose of data collection is part of contracts with crowd observatories.

4.1.3. Data minimization

Data collection should be strictly limited to the purpose as defined above. For CrowdDNA video database, that could for example mean that video resolution is adjusted so that crowd behaviors remain visible in images while we limit the identification of individuals in images at the same time by downsizing resolution.

4.1.4. Accuracy

The data collection is subject to manual verification to ensure that data, for instance, is not corrupted, or damaged.

4.1.5. Storage limitation

Any storage of personal data should be limited: in accessibility, in size and in time. Four crowd observatories, applying the data minimization principle, we attempt to delete personal data. If successful, only privacy-free data will be kept with no limitation of time.

4.1.6. Integrity and confidentiality (security)

Crowd observatories data management follows the principles defined on the data management plan of the CrowdDNA projects, using secured storage systems with access controls. Internally, for example at INRIA, the data management and processing are subject to a security analysis document, supervised and validated by internal experts.

4.1.7. Accountability

CrowdDNA is capable of providing proof that the principles above are followed in our procedures. For instance, at INRIA, the internal ethical board (COERLE) is informed and validates the data collection and management procedures we follow, and is responsible for ensuring the procedures are followed.

4.1.8. Privacy Policies

Observatories that are participating in the CrowdDNA project are advised to update their privacy policies to include a short piece of information about their involvement in the project and a link and/or contact details for the project.

4.1.9. Participation Signage

Signs outlining brief details about CrowdDNA and the observatories participation in the project should be displayed on site. Preferably a QR code should be included for ease of access to the CrowdDNA website.

4.2. Legal Contracts with Observatories

4.2.1. Hellfest

The experiments conducted at Hellfest have been the subject of an agreement between INRIA and Hellfest. In summary, this agreement provides for:

- That Hellfest agrees to give access to the festival site to allow the preparation and the realization of experiments within the framework of CrowdDNA.
- That Hellfest allows us to inform the public of the presence of experiments on the site (legal obligation regarding data collection).
- That Hellfest is released from any responsibility regarding the object and the means used for the realization of these experiments.
- That Hellfest has the right to access the data collected.
- That Hellfest has the right to review and veto any communication actions related to our experiences that could affect the image of the festival.

Figure 4.1– (Left) Signs at the entrance of the festival; (Right) T-shirts wore by our staff during festival

4.2.2. Tramlines & ArcTanGent

Observatories are required to update their privacy policies to state their involvement in the CrowdDNA project. The privacy policy needs to link to the CrowdDNA website. During participation, observatories are required to display signs stating their involvement in CrowdDNA with a link or QR to the CrowdDNA website. Examples below from Tramlines and ArcTanGent:

Figure 4.2 - (Left) Sign Displayed at Tramlines; (Right) Sign Displayed at ArcTanGent (in multiple places)

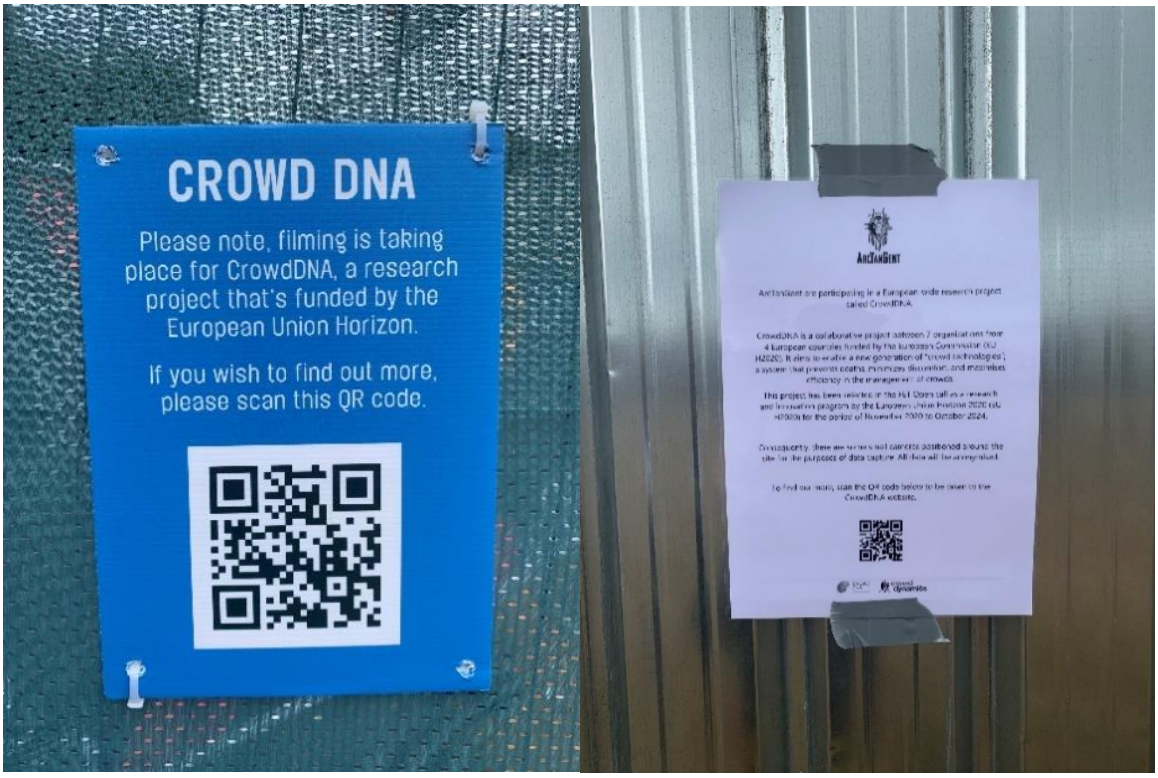


Figure 4.3 - ArcTanGent Privacy Policy extract

Research Participation

ArcTanGent is participating in a European-wide research project call CrowdDNA. CrowdDNA is a collaborative project between 7 organisations from 4 European countries funded by the European Commission (EU H2020). It aims to enable a new generation of "crowd technologies"; a system that prevents deaths, minimizes discomfort, and maximises efficiency in the management of crowds.

This project has been selected in the FET Open call as a research and innovation program by the European Union Horizon 2020 (EU H2020) for the period of November 2020 to October 2024.

More information can be found here: www.crowddna.eu or you can contact the lead partner via the contact form: Contact – CrowdDNA

Contact Us
Please contact us at info@arctangent.co.uk if you have any questions, requests, or complaints regarding the use of your personal data.

5. Installed Observatories

5.1. Schedule/summary

Hellfest 17th – 26th June 2022 (two weekends) – data capture took place on 17th – 19th June 2022

Tramlines 22nd – 24th July 2022 – data capture took place on the 22nd and 23rd July 2022

Bloodstock 11th – 14th August 2022 – data capture took place on the 12th August 2022

ArcTanGent 17th – 20th August 2022 – data capture took place on the 18th August 2022

Figure 5.1 - CrowdDNA Observatory Locations, Summer 2022

5.2. HellFest

5.2.1. Description

Hellfest is Europe's largest extreme music festival, and takes place in Clisson, Loire Atlantique, France, usually between mid and late June. The 2022 edition was the fifteenth, coming after two years of cancellation due to the global SarsCov2 pandemic: the 2022 edition was particularly long, taking place over 2 consecutive weekends from June 17th to 19th, then from June 23h to 26th as a result.

The festival gathers about 70,000 people per day, 60,000 paying festival-goers, 5,000 volunteers, and the rest as guests of the festival, but also mostly technicians and professionals working directly for the festival. The festival includes 6 music stages, playing in pairs, allowing a continuous broadcast of concerts on 3 active stages simultaneously. Each stage is dedicated to a specific style of metal music. CrowdDNA's observations have all been on the "Warzone" stage, which curates hardcore metal.

5.2.2. Plan of site

The Hellfest site is specific. Unlike the majority of other festivals, part of the installation of the festival is static whole year round. Stages and all technical installations are temporary, while part of the decoration of the festival is static. Figure 5.2 shows a general plan of the site, the site is contained in a diagonal rectangle of approximately 850x450 meters, which includes various zones. The “Warzone” area, which was the focus of CrowdDNA’s involvement in the festival, is highlighted on the below image.

Figure 5.2 - General Map of the Hellfest Festival Site

CrowdDNA experiments at Hellfest took place at the "Warzone", which is a stage dedicated to hardcore metal music where lot of intentional crowd movements take place, which include lots of physical interactions through moshing, mosh pits, circle pits, "walls of death" and crowd-surfing. See Figure 5.3 for a plan of the area.

Figure 5.3 – Detailed Plan of the Hellfest "Warzone"

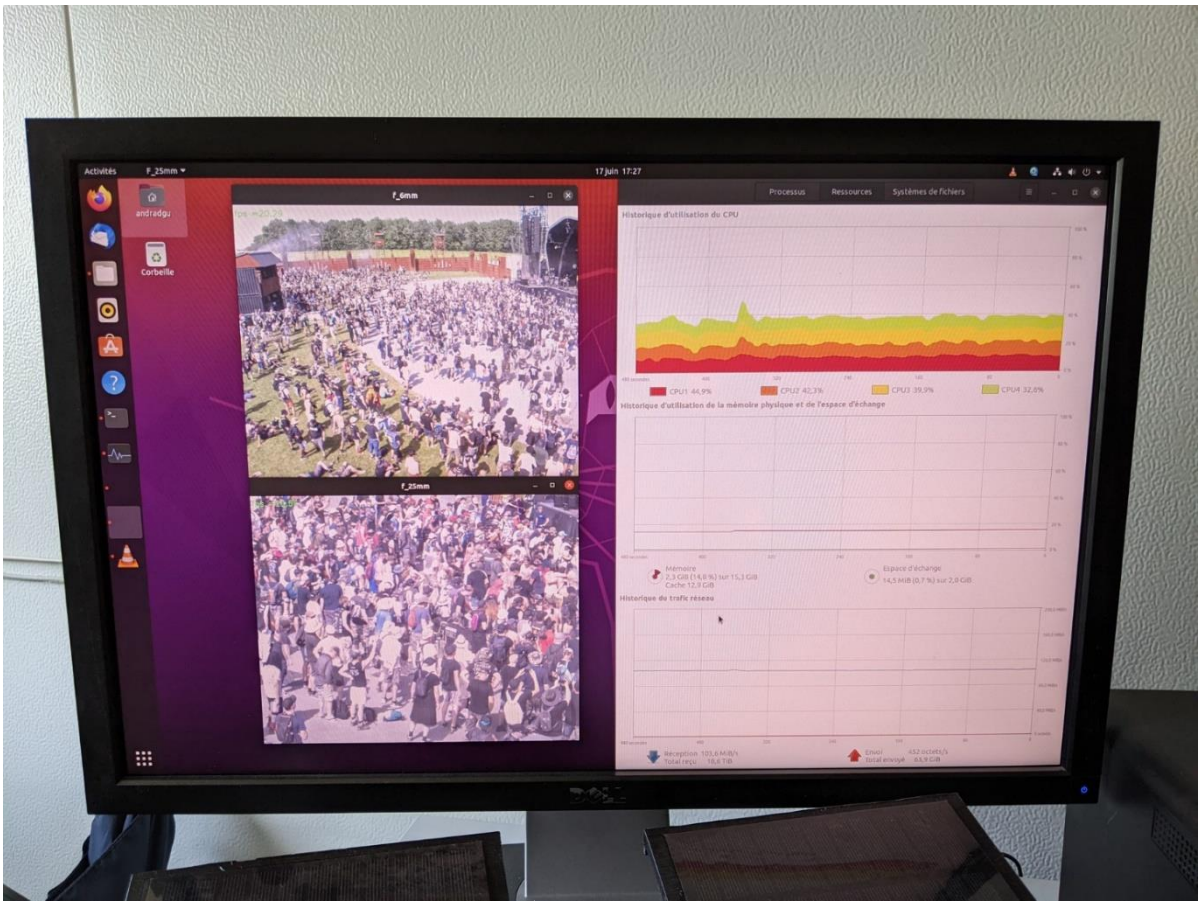
5.2.3. Data plan

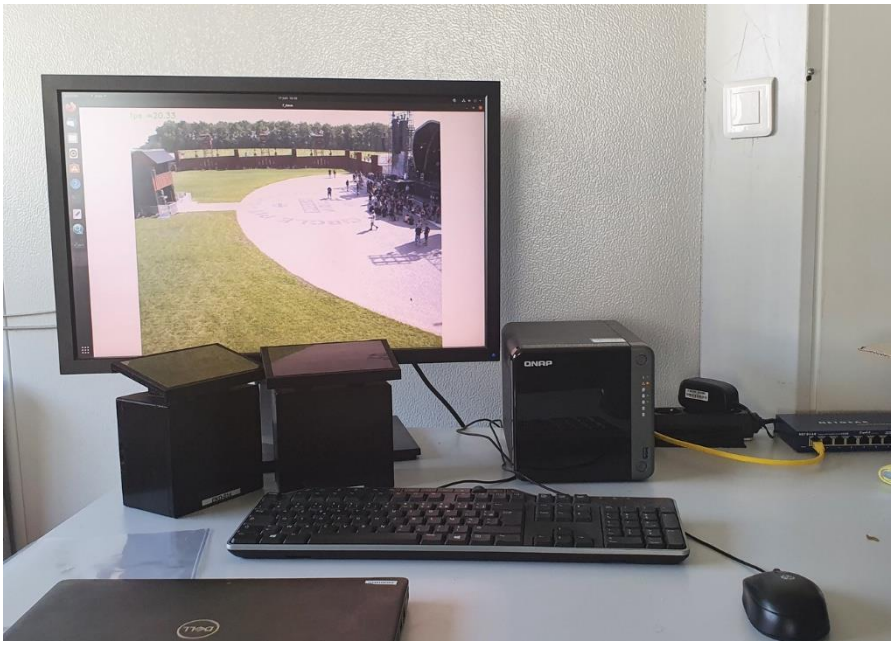
5.2.3.1. Video

The objective of getting video data was to get an estimate of crowd movements in a place of high density of public with physical interactions. The public in front of the Warzone stage was ideal for this purpose. In the ethical agreement we obtained for collecting our video content, the resolution of videos is restricted to prevent easy identification of people in the public, while keeping the resolution high enough to estimate movement: this allow us to spot and track our confederates wearing specific hats and tally the data with together with the Xsens suits. For this reason, video data was gathered from the 2 GiGE cameras fixed on the "Warzone" area. Both cameras were oriented to the public attending concerts in the warzone. Having lenses with different focal length, we could have a range of resolutions.

A screenshot of the computer collecting data below shows the viewpoint. Video streams were continuously captured and stored. The high temperatures the festival experimented (up to 40°C) resulted into a number of technical issues related to the network we used to transfer video data. This generated temporary loss of data that could not be transferred.

Figure 5.4 – Top : snapshot of the PC we used to watch video recordings live, and network capacities. Bottom : another picture of the same PC, showing the large angle camera view, as well as the NAS drive used to store more safely all video recordings.





Cameras were mounted on a “mirador” next to the public of the warzone. They were clamped with fixation arms.

Map showing the location of the mirador to which camera were fixed.

Figure 5.5 - Map showing the location of the mirador to which camera were fixed

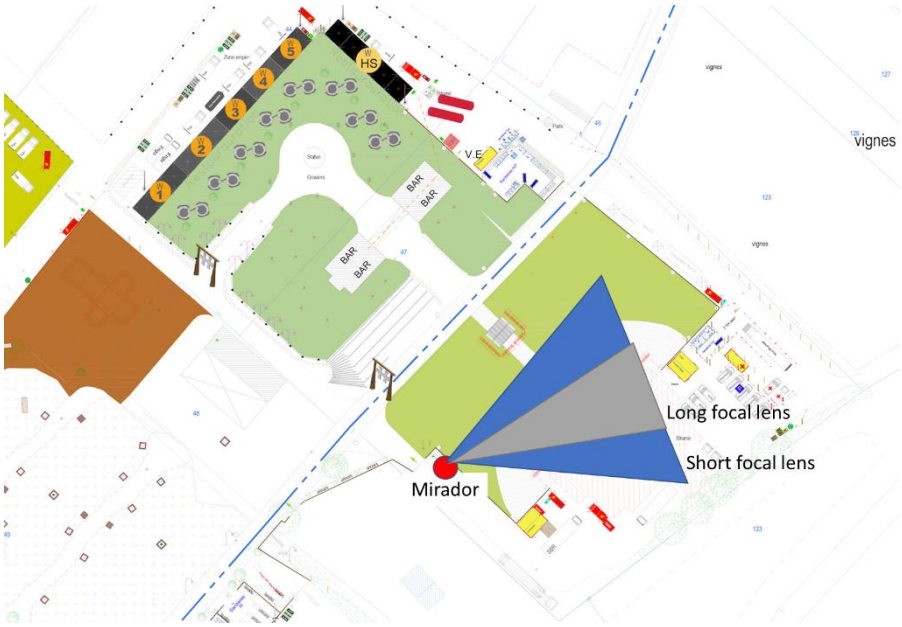


Figure 5.6 - Pictures showing the mirador, with location of the fixation point

Figure 5.7 - Large view of the warzone stage, with the mirador on the right

Figure 5.8 – (Left) Orange was worn by our confederates to be easily spot on camera images; (Right) Tee-shirt with information about the project

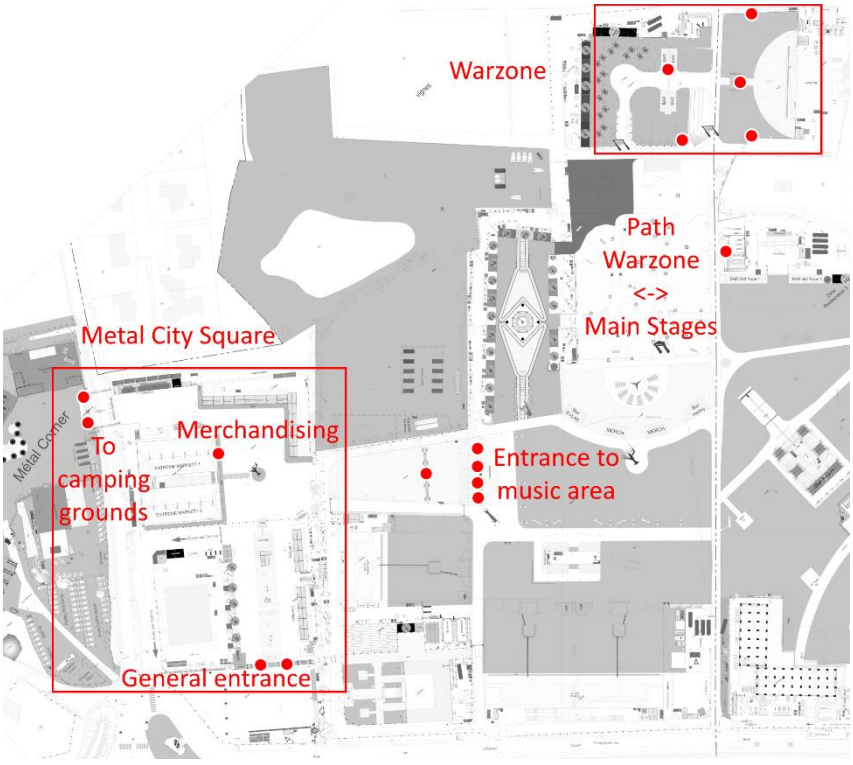
5.2.3.2. Bluetooth/WIFI

As previously stated, the main area of focus for the experiments at Hellfest was the Warzone. As these experiments concern large and dense crowds, knowing, even roughly, how many people are involved is important. Since the cameras installed at the Warzone were not meant to cover the entire crowd, they could not be used for this purpose. Instead, this could be achieved through IoT tracking.

First, the ratio of IoT devices to festivalgoers needs to be established by comparing the total number of attendees with the number of IoT measurements. Second, this ratio would need to be applied to measurements carried out at the Warzone. The locations of all sixteen IoT sensors installed at the Hellfest can be seen on Figure 5.. Five of them were installed at the only entrance to the part of the site where music is played (other, smaller entrances exist, but they are for staff only), thereby making it possible to compare the number of ticket validations with the number of unique MAC addresses at this entrance. Then, another five sensors were installed at the Warzone at regular intervals: three close to the stage and two at the rear of the crowd closer to sources of food and drinks. In addition to these five sensors, a sixth was placed near the path which connects the Warzone and the two main stages, as this is the path most people usually take.

As can be seen on Figure 5., five more sensors were deployed in the Metal City Square. The reason is that this part of the site, which can be accessed without tickets, hosts various merchandising outlets, thereby inciting festivalgoers to move back and forth between here and the music area. Additionally, Metal City Square connects the only entrance of the music area with the two outer entrances: the general entrance, and the one leading to the camping grounds. This area thus contains a sizeable amount of crowd movement, with multiple possible destinations. On top of this, the origins of attendees' paths can inform the composition of the crowds onsite: between visitors with remote commodities and those that can more easily rest between performances. While these kinds of information are less directly linked to the events at the Warzone, they are nonetheless important to understand the general crowd behaviours at the Hellfest. The five Metal City Square sensors were thus deployed as follows: two at the general entrance, two at the entrance from the camping grounds, and a final sensor at the main merchandising area.

Figure 5.9 - Red dots: locations of the Sixteen IoT Sensors



5.2.3.3. XSens

5.2.4. Site Attendance

XSens delivered motion capture data for research participants interacting in concerts at the warzone, in the area covered by our cameras. Recordings were organized as follows. Each day of the festival, we spotted 1 or 2 concerts with high chances of intense crowd movements (emerging from dancing). 2 confederates wore an Xsens suit and joined the public of these concerts. They were followed each by another member of the team, to watch them and help them when needed. Confederates participated to the concerts as they would do usually (most of confederates were used to go to metal music festivals).

Figure 5.10 - (Left) picture of one research participant wearing a Xsens suit and doing crowd surfing. (Right) Picture shows the image perceived by the cameras and motion recorded with the Xsens suit.

Figure 5.11 – Preparation of the suit backstage

Figure 5.12 - Calibration stage before and after concerts

5.2.4.1. Photos

Figure 5.13 - Aerial views of the Hellfest site (from the Great Wheel)

5.2.4.2. Observations

The 15th edition of the Hellfest festival gathered 60.000 people each day. This guaranteed us to have dense crowds in the area. The wifi / Bluetooth detection revealed the large attendance of the festival. Over the seven days of the festival (June 17-19, 23-26), 154 000 000 Bluetooth and 9 000 000 WiFi detections have been recorded, which now need processing in order to roughly reconstruct the crowd movements onsite.

5.3. Tramlines

5.3.1. Description

Tramlines Festival is held in Sheffield, UK on the 22nd - 24th July 2022. The festival was curated and organised by a panel comprising local venue owners, promoters, and volunteers. The name of the festival is inspired by the city's tram network. Tramlines held its first festival in 2009, which attracted 35,000 fans across Sheffield city centre. It has now moved to Hillsborough Park attracting 40,000 people each day (120,00 in total). Tramlines has five stages which host a combination of live music, comedy, a pop-up cinema, and a dedicated family area.

5.3.2. Plan of site

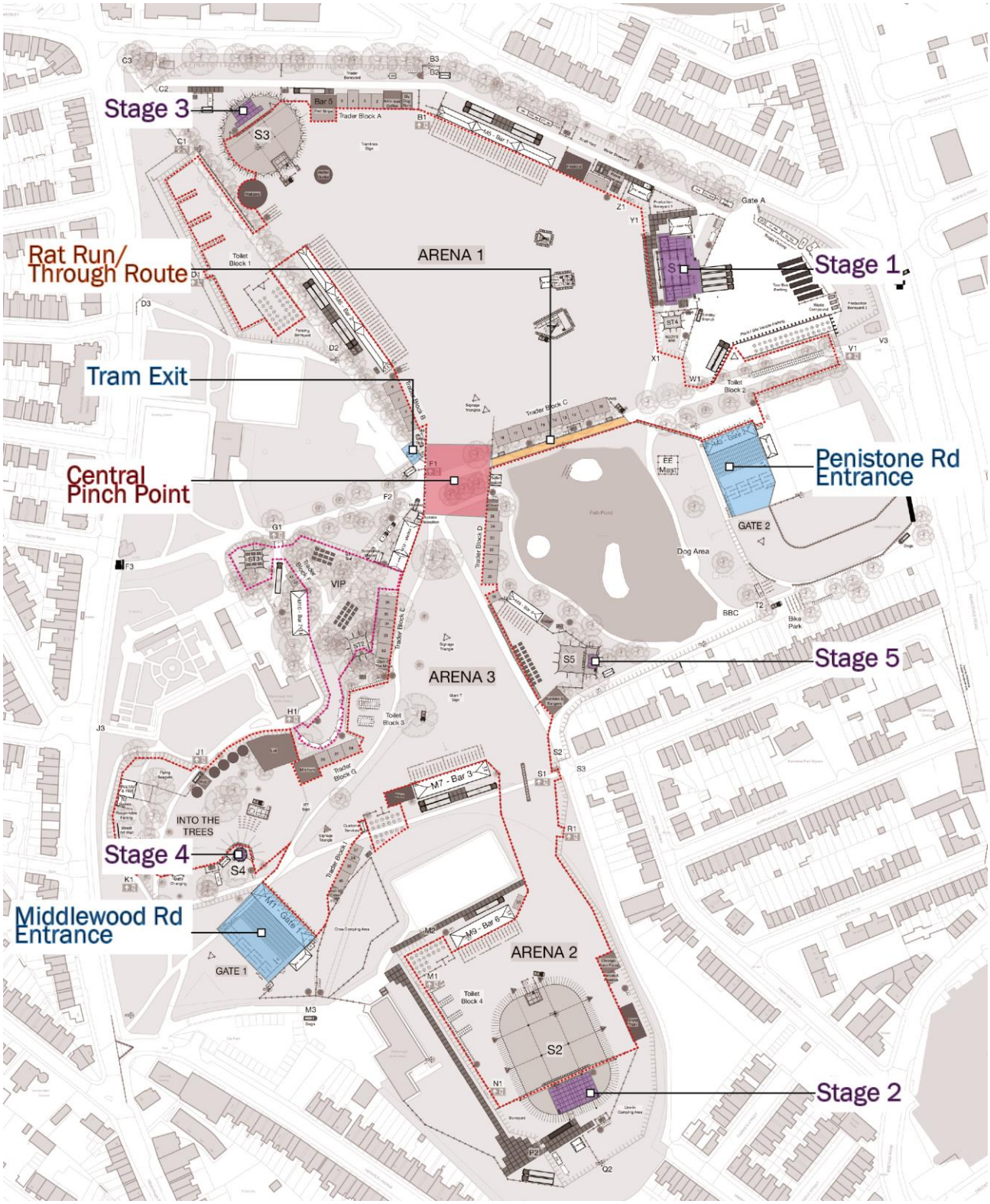
The Tramlines site was split into three main arenas (shown below). Arena 1, located at the north of the site, was the location of the main stage as well as Stage 3 (the Leadmill Stage). Arena 2 to the south was the site of Stage 2 (T'Other Stage), with Arena 3, located in the center of the site, playing host to food & beverage stalls, as well as seating, the welfare tent, and the VIP enclosure.

A plan of the Tramlines 2022 site is shown below in Figure 5.4.

Figure 5.14 - Tramlines 2022 Site Map

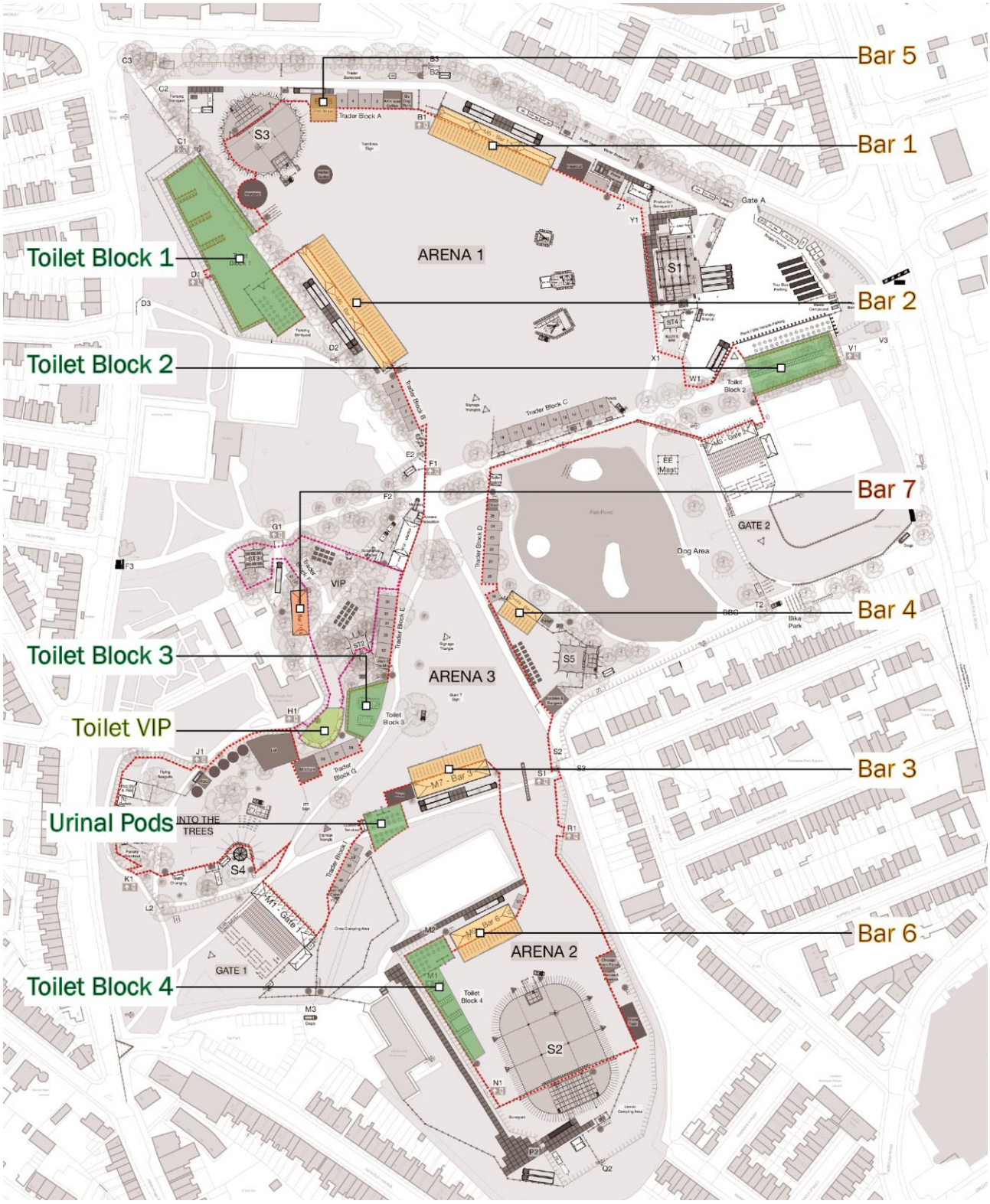
The names and locations of the stages, as well as entrances, and other points of interest across the site where recording took place can be seen on the map below:

Figure 5.15 - Tramlines Observatory Key Points of Interest



The names and locations of all toilets and bars throughout the site are highlighted on the map below:

Figure 5.16 - Tramlines 2022 Bar & Toilet Locations



5.3.3. Data plan

5.3.3.1. Video

A full log of all videos captured as part of the Tramlines observatory, detailing time of recording, length, location, as well as key information about the contents of each recording can be found in the Video Log, as described in 3.2.1 of this report. Key observation areas and site walkthrough routes are shown on the Tramlines site map in Figure 5.7 below.

Figure 5.17 - Key Observation Areas and Walkthrough Routes

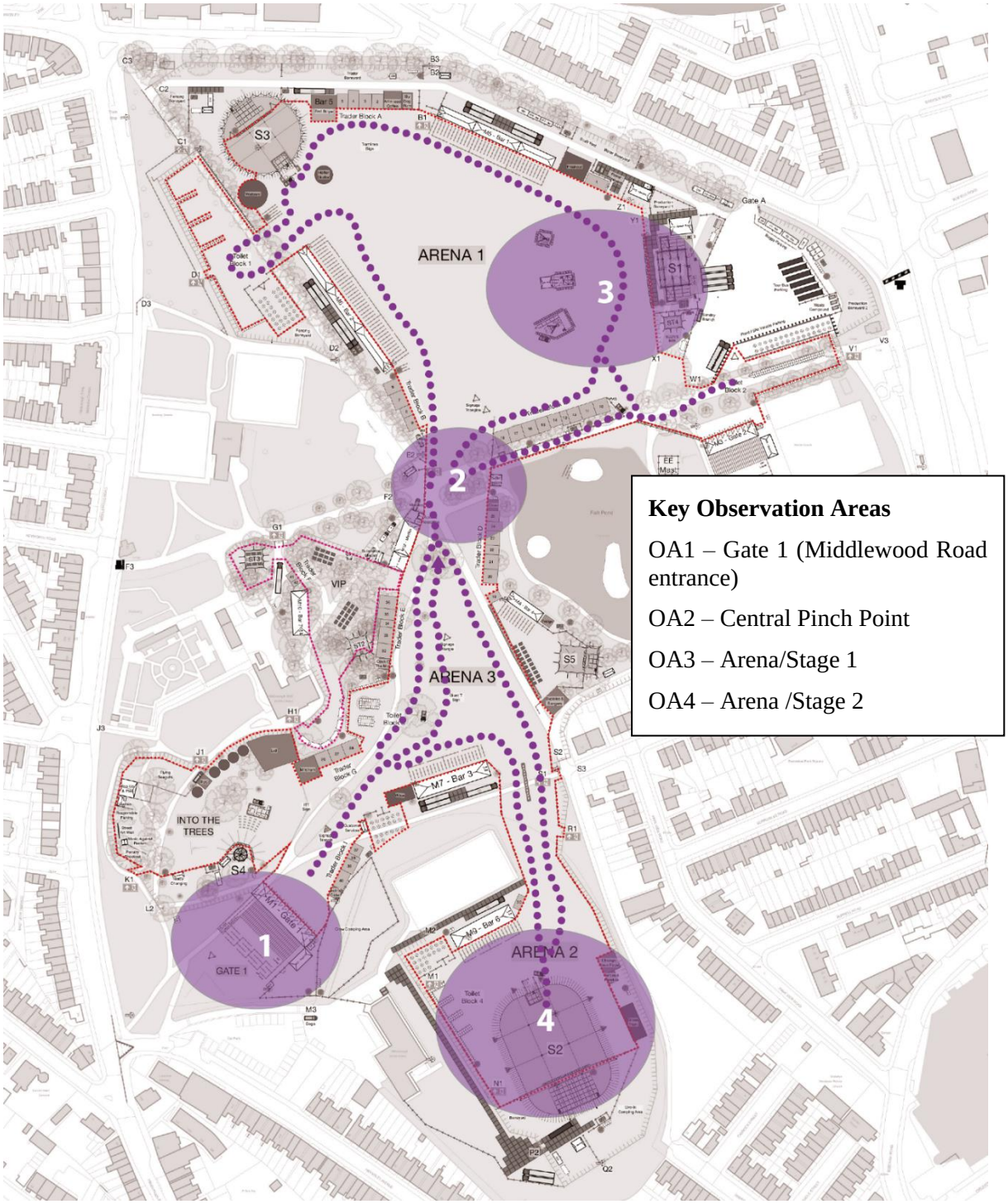
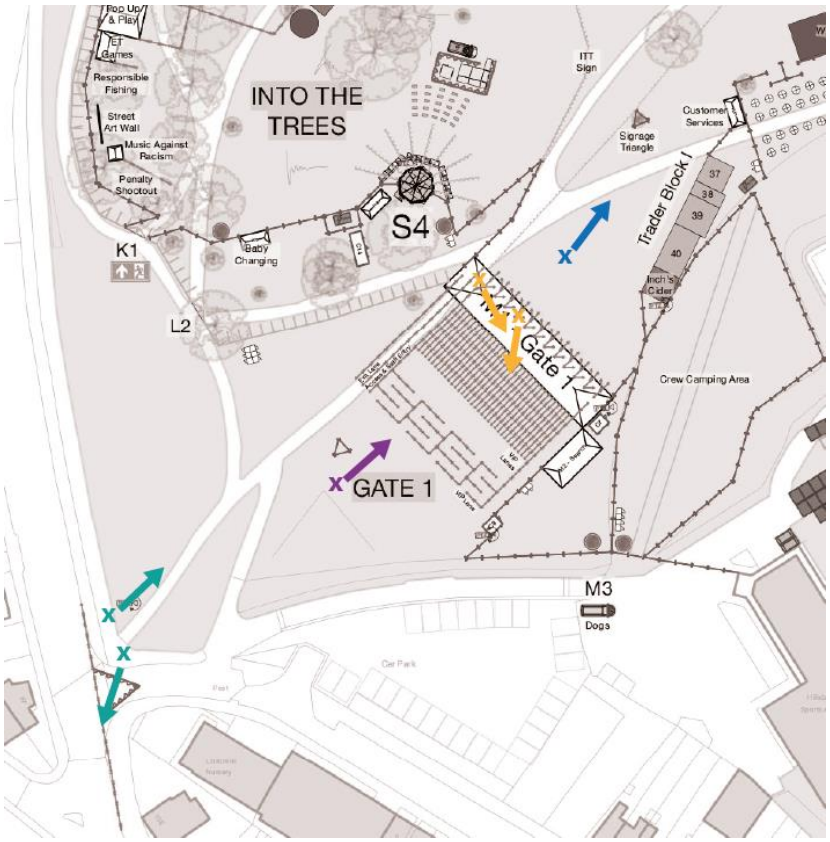


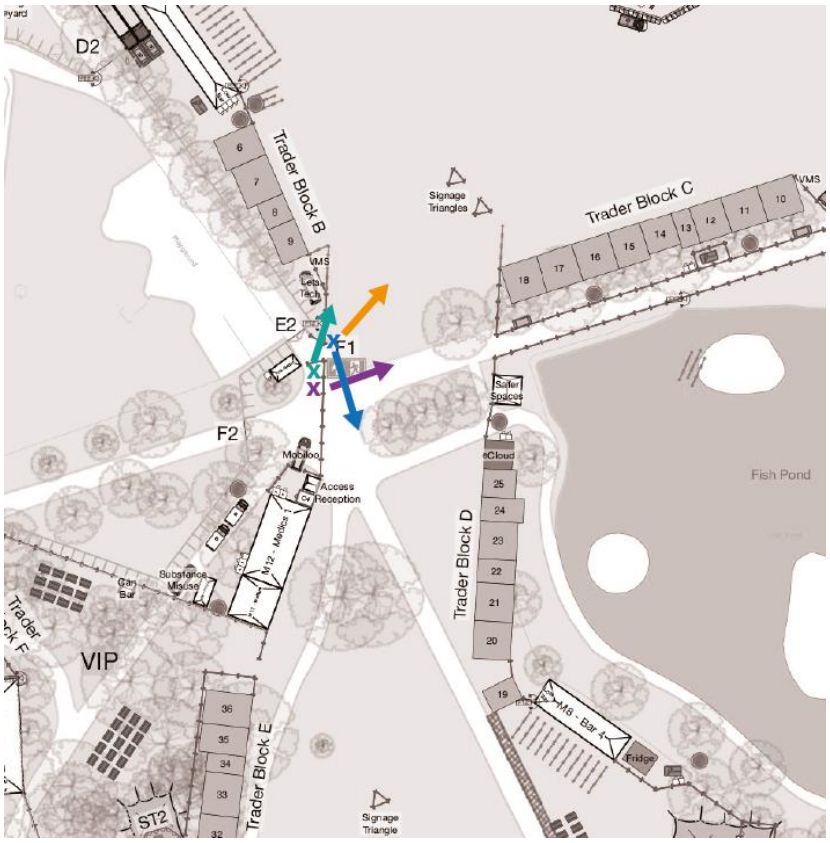
Figure 5.18 - Observation Area 1 (Gate 1)



OA1 - Camera Locations

1. Inside the marquee capturing security and ticket check (orange)
2. Ingress and dispersion into site / arena 3 (blue)
3. The queue and people movement (purple)
4. Arrival people movement (cyan)

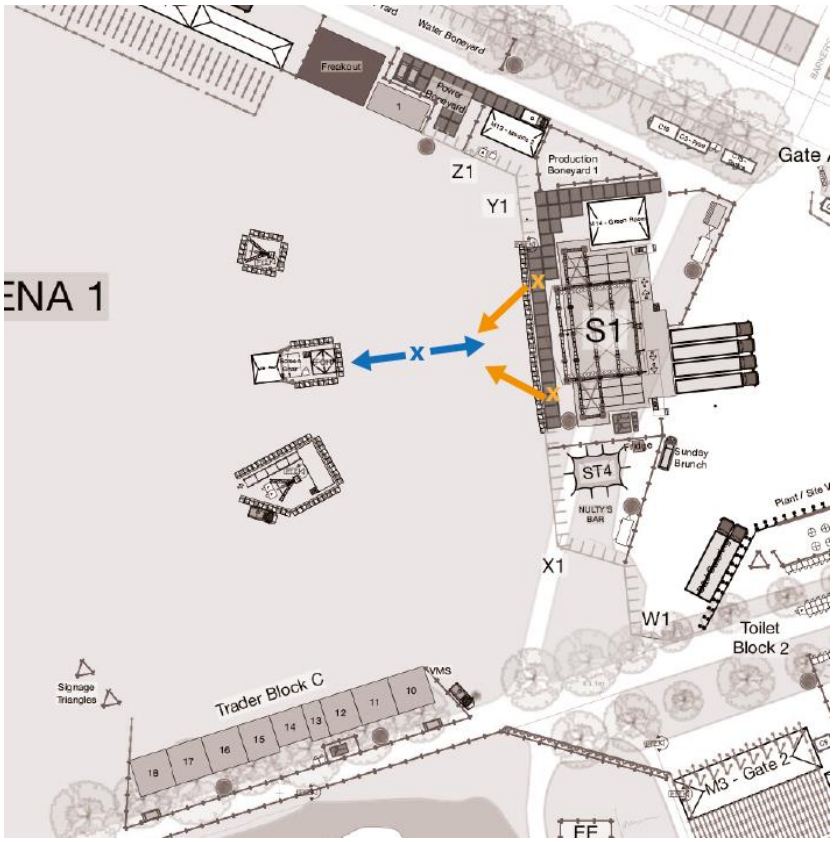
Figure 5.19 - Observation Area 2 (Central Pinch-point)



OA2 - Camera Locations

1. Normal crowd movement to/from Gate 1 and Stage 2 (blue)
2. Normal crowd movement to/from Arena 1 and Gate 2 via Rat-run/Through-route (purple)
3. Normal crowd movement from Stage 1 and overview of Arena 1 (orange)
4. Arrival people movement (cyan)

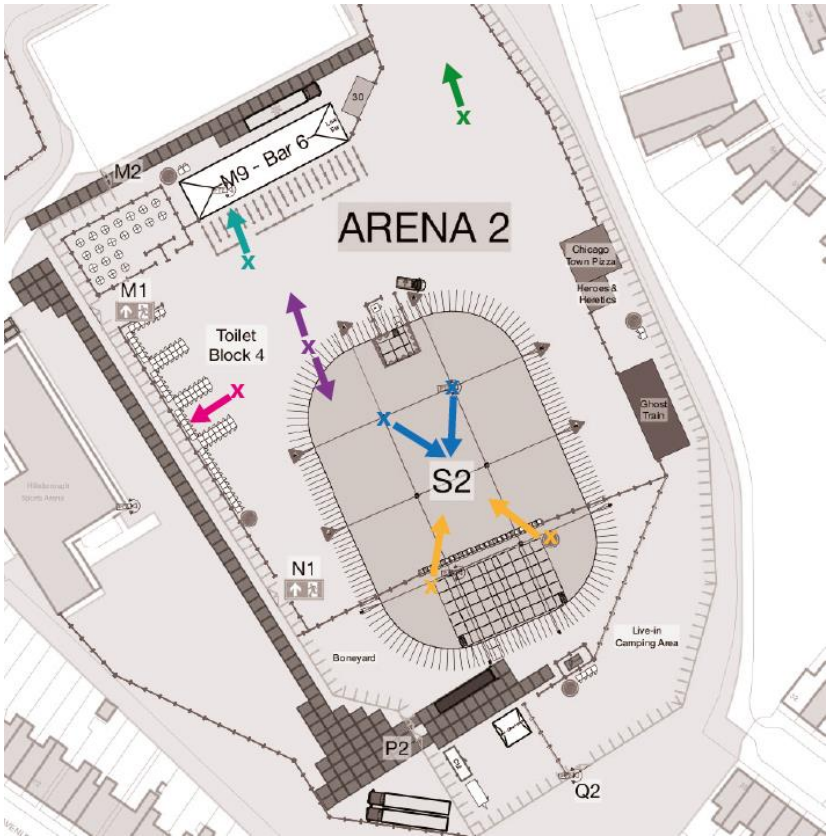
Figure 5.20 - Observation Area 3 (Arena 1/Stage 1)



OA3 - Camera Locations

1. Crowd filmed from the pit (orange)
2. Crowd filmed from within the crowd in a forward and backwards direction (blue)

Figure 5.21 - Observation Area 4 (Arena 2)



OA4 - Camera Locations

1. Crowd from the pit barrier (orange)
2. Tent filling up before a set and emptying afterward (blue)
3. Stage ingress/egress at big top performance (purple)
4. Toilet queue post-busy performance (pink)
5. Bar queue post-busy performance (cyan)
6. Arena 2 ingress/egress during big top performance (green)

5.3.3.1 Ingress

Two separate ingress locations were in operation for Tramlines; Gate 1 located on the corner of Middlewood Road and Hawksley Avenue, and Gate 2, located to the west of Parkside Road. Sperate lanes were in operation for General Admission, VIPs, and Production, with an additional staff entrance provided on Parkside Road to the north of Arena 1.

A no re-entry policy was enforced for visitors across the site, with no wristbands exchanged for tickets on entrance. Prior to ticket-check, bags were searched and scanned. No food was permitted to be brought into the arena.

Figure 5.4 – (Top) Security Barriers at Gate 1; (Bottom) Manual Bag Search Area

5.3.4. Site Attendance

CrowdDNA Observatories attended the Tramlines festival on Friday 22nd and Saturday 23rd July 2022. Observatories were on site between 10:00 and 23:00, in order to capture footage of both ingress and egress, as well as all previously identified points of interest throughout the two days.

5.3.4.1. Photos

In addition to the video footage of site walkthroughs and of crowds throughout the festival, photos were taken to provide additional context to the video locations. Photos taken are presented throughout this section.

Figure 5.23 shows the Penistone Road entrance, and was taken from inside the festival site, prior to the arena opening on Saturday 23rd July. The largest toilet area on site was located by this access and can be seen to the left of this image.

Figure 5.23 – Penistone Road Entrance

Figure 5.24 - Middlewood Road Entrance, South of Arena 3 (Entrance 1)

Figure 5.24 was taken at the Middlewood Road entrance, located to the south of Arena 3. The image was taken from outside the site, looking in, as the queues built ahead of the 12:00 opening time on Friday 22nd July.

Signage

Figure 5.25 shows the CrowdDNA signage which was placed around the site ahead of the festival opening. Signs displayed a QR code which linked to the CrowdDNA website, where more information regarding the details of the project and the privacy policy could be found.

Figure 5.25 - CrowdDNA Signage at Tramlines Festival

Central Pinch-Point & Through-Route

Figure 5.226 shows the pinch-point identified in the center of the site, located between arena 1 and arena 3. The image was taken facing Stage 2, which can be identified in the distance as a red marquee.

Figure 5.26 - Central Pinch-Point

Figure 5.27 below shows the through-route which runs alongside Arena 1, between the Penistone Rd entrance and the central pinch-point shown above. Arena 1 can be seen on the right-hand side of the image, with the pinch-point observed in the distance. Both the above and below images were captured on Saturday 23rd July, ahead of the site opening.

Figure 5.27 - Through-Route

Stage 2

Much of the recording captured at Stage 2 was taken from the pit between the stage and crowd barriers, with all footage taken facing towards the audience, as shown in **Erreur ! Source du renvoi introuvable.**8.

Figure 5.28 - Crowds from Arena 2 'Pit'

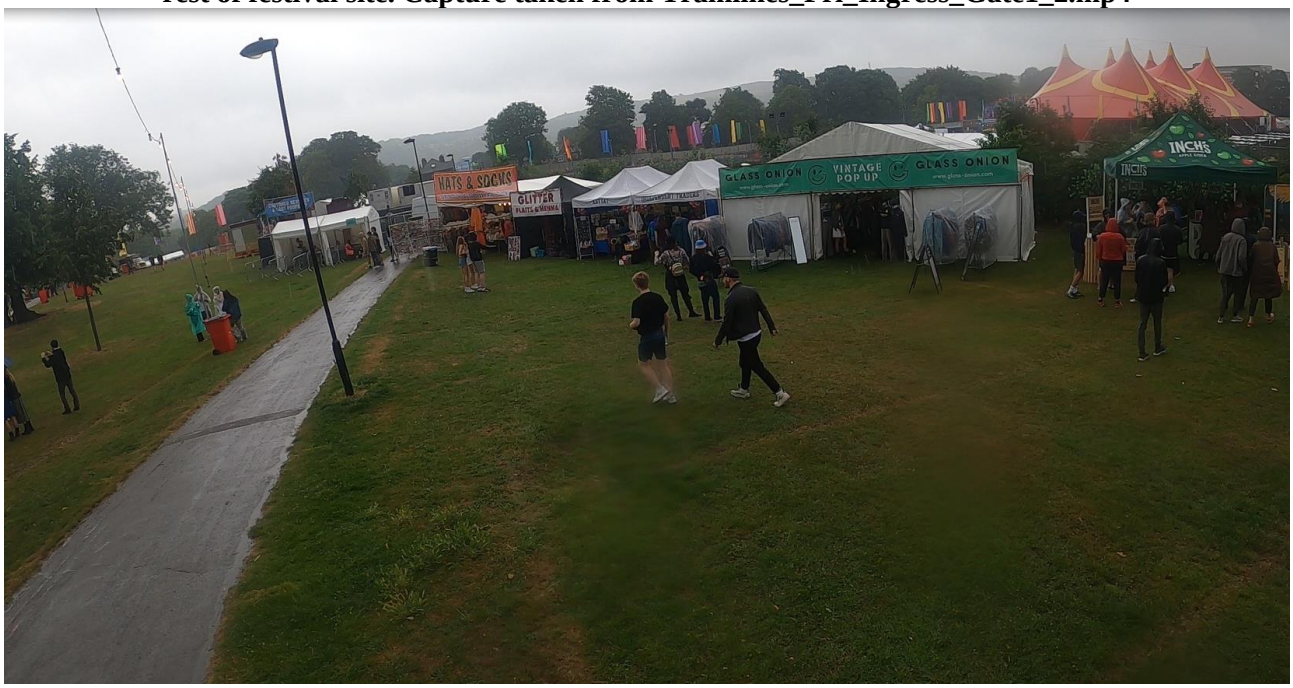
5.3.4.2. Video

Videos were captured from vantage points throughout the site, as described in section 5.3.3 of this report. This section shows the views from each of the camera angles used, via snapshots of the video footage taken. A reference to the video file from which a capture is taken from is provided in each description.

Middlewood Road Entrance (Entrance 1)

Figure 5.29 - Video Location - View of Middlewood Road Entrance, south of Arena 3, as ingress begins at 12:00 on Friday 22nd July. Capture from Tramlines_Friday_Bag_Check_Gate1.mp4.

Figure 5.30 - Video Location - View from beyond Entrance 1 (Middlewood Rd), facing into Arena 3 & rest of festival site. Capture taken from Tramlines_Fri_Ingress_Gate1_2.mp4



MAIN STAGE

Videos were captured during performances on Stage 1 from the 'pit', between the stage and the crowd barriers. This area is typically occupied by security, production crew, and press photographers.

Figure 5.31 - Video Location - (Left) Stage 1 'pit', shot from stage right, facing central pinch point and front of house. Capture was taken from Tramlines_Sat_Stage1_SR_Afternoon_1.mp4); (Right) Stage 1 'pit', shot from stage left, facing Leadmill Stage (Stage 3). Capture taken from Tramlines_Sat_Stage1_SL_Afternoon_1.mp4.

Recordings were also taken from the Stage 1 Front of House (FOH), and from the center of Arena 1, facing the FOH, as shown below in **Erreur ! Source du renvoi introuvable.** and **Erreur ! Source du renvoi introuvable.**.

Figure 5.32 - Video Location – Stage 1 from FOH, taken from Tramlines_Sat_Stage1_FOH_1.mp4.

Figure 5.33 - Video Location – Center of Arena 1, facing the FOH, from Tramlines_Sat_Stage1_FOH_1.mp4.

STAGE 2

Stage 2 was hosted inside a marquee, and as such, poor lighting has affected the quality of some footage captured later in the evening. Figure 5.34 - Video Location – and **Erreur ! Source du renvoi introuvable.** below shows the view from pit during the Lady Leshurr set at approximately 19:00 on Friday 22nd July.

Figure 5.34 - Video Location – (Left) Stage 2 'pit', shot from Stage Left facing center of Marquee, from Stage2_SR_LadyLeshurr_3.mp4; (Right) shot from Stage Right, from Stage2_SR_LadyLeshurr_5.mp4

On Saturday July 23rd, videos taken from Stage 2 we're captured from the FOH, facing the stage, rather than from the pit. show the camera angle used to capture crowds egressing Stage 2, as well as crowds watching performances on Stage 2

Figure 5.35 - Video Location – Stage 2 shot from Left of FOH, from Stage2_FOH_SamRyder_PreShow_1.mp4 & Stage2_FOH_SamRyder_PreShow_1.mp4 (Left & Right Respectively)

Figure 5.36 - Video Location – Stage 2 shot from Right of FOH, from Stage2_BR_SamRyder_Show_1.mp4 & Stage2_FOH_Kawala_Egress_1.mp4 (Left & Right Respectively)

CENTRAL PINCH POINT AND THROUGH-ROUTE

The central pinch point and through-route were identified as key areas for observation during the festival. The central pinch-point is located between Arenas 1 and 3, and experiences high footfall, particularly in between acts performing on Stage 1. The through-route runs between the central pinch-point at one end, and the Penistone Road Entrance at the other. The central pinch-point was filmed from two angles, shown below.

Figure 5.37 - Video Location – Adjacent to Central Pinch-Point, facing Through-Route to Penistone Rd Entrance, from Tramlines_Fri_Adj_pinchpoint_Evening_2.mp4

Figure 5.38 - Video Location – Opposite Central Pinch-Point, facing Arena 2, captured from Tramlines_Fri_Opp_Pinchpoint_Evening_5.mp4

BARS & TOILETS

Queues at bars and toilets were recorded between key sets over the course of the two days CrowdDNA were on-site. Queues at Bar 6, located in arena 2 were recorded from 2 locations to the rear of the Stage 2 marquee, from the locations shown in **Erreur ! Source du renvoi introuvable.** Figure 5.39 - Video Location – (Left) Bar 6 From Rear of Stage 2 Marquee; (Right) Video Location 5.1 . Footage of bar and toilet queues was predominantly captured on Saturday 23rd July. The image was taken from Tramlines_Sat_Arena2_FnB_1.mp4.

Figure 5.39 - Video Location – (Left) Bar 6 From Rear of Stage 2 Marquee; (Right) Video Location 5.1 - Bar 6 Close-up

Figure 5.40 - Video Location – Toilet Block 4, Arena 2, from Arena2_ToiletQueues_1.mp4.

Queues at other toilet blocks located throughout the site were captured during site-walks, cand can be seen in the following videos:

- Tramlines_Fri_Evening_Arena1_Sitewalk_1.mp4
- Tramlines_Fri_Evening_PinchpointToS2_Sitewalk_2.mp4.

EGRESS

Video footage of crowds egressing the festival site were taken on Friday 22nd July from two different exit points; the exit to Leppings Lane Tram Stop, and the Middlewood Road exit (previously referred to as Entrance 1). Low-lighting prevented capture of higher-quality egress footage at main entrance, whilst significantly better lighting was provided on-site at the Tram Stop exit, as it was located closer to Arena 1.

Erreur ! Source du renvoi introuvable. shows the camera angle used to capture crowds egressing towards the Leppings Lane Tram Stop. Arena 1 and Stage 1 can be seen in the upper left corner of the image, with the video capturing crowds making a U-turn around the Arena 1 entrance to egress the site. This exit remained closed throughout the day but was opened during the final performance on the main stage, to allow crowds to leave.

Figure 5.41 - Video Location – Leppings Lane Tram Stop Egress, from Tramlines_Fri_Tram_Egress_2.mp4.

At the Middlewood Road exit, some barriers were removed from the security tent, to facilitate greater flow of crowds through the exit. This can be seen in **Erreur ! Source du renvoi introuvable.** below.

Figure 5.42 - Video Location – Middlewood Road Entrance Egress, from Tramlines_Fri_Main_Egress_1.mp4.

5.3.4.3. Site Observations

Transport

- No public parking available
- Very limited staff and crew parking, all off site apart from production vehicles
- Surround roads heavily stewarded with event signage but no real prevention to stop event traffic from parking on residential streets
- Signage for staff and crew parking was very sparse

Entrances: Security and Ticket Check

- Consistent flow of people from midday to 4pm (approx.)
- Surge of people to coincide with tram arrivals
- Snaked pedestrian barrier to allow for queues if they formed
- Never overly busy
- VIP, general and mobility queue
- No re-entry policy
- Bag checks on every bag – labelled to show they had been searched
- Large number of people using printed tickets rather than e-tickets – causing a slowdown in ticket redemption

Central Pinch Point & Rat-run

- During the day, congestion did not prevent a suitable level of crowd flow
- Pavement edge sprayed yellow to highlight trip hazard
- In wet weather, a requirement for trackway or similar would be required
- Suggested rat-run would be manned to make it a one-way flow; wasn't implemented or required on site (apart from egress)

Main stage

- Deep pit to allow for security, photographers, production, key staff to pass through

Second stage

- Narrower pit, security & press could pass through but with less comfort than main stage

Food and Beverage

- Busy/congested area at peak times
- Toilets in this area not sufficient

Bars

- Extensive bar width reducing queues
- Queues formed predominantly between bands
- One-way in and out system implemented to prevent friction between groups moving to and from bars

VIP Area

- Poor signage/wayfinding, security asked several times where VIP area was
- Slower food concessions as stalls prepared fresh food rather than "Grab & Go" style meals
- Bar queues similar length or longer than general admission bars
- Short toilet queues

Toilets

- Toilets positioned in u-shape formations, makes the queue/waiting area congested between bands; often hard to see when a toilet becomes available. Formation does optimise the number of toilets in a space.
- Request for a baby change facility station at each toilet block, especially in wet weather.
- Insufficient toilets at F&B area in the middle of the site

- Lack of urinals in middle of site
- No female urinals

Water points

- Hard to find, signage in the wrong place
- Insufficient water points across the site
- Bars not topping up water bottles

Egress

- A lack of lighting
- Crowd leaving from main stage to leave via exit near the central pinch-point have to go back on themselves – causes confusion
- Lack of visible egress signage
- Lack of wayfinding (most staff being approached were well-informed of the locations for taxi, bus and tram stops)
- Awaiting CCTV footage of egress for analysis

5.4. Bloodstock

5.4.1. Description

Multi award-winning Bloodstock Open Air (B-O-A) is the UK's biggest independent metal festival. Held at the picturesque location of Walton on Trent in Derbyshire, UK since 2005. Originally held indoors for one day with two stages, the festival started in 2001 at the Derby Assembly Rooms and has expanded over the years. It became an outdoor event in 2005. Bloodstock hosts 5 stages, across 4 days and has a capacity of around 18,000 people.

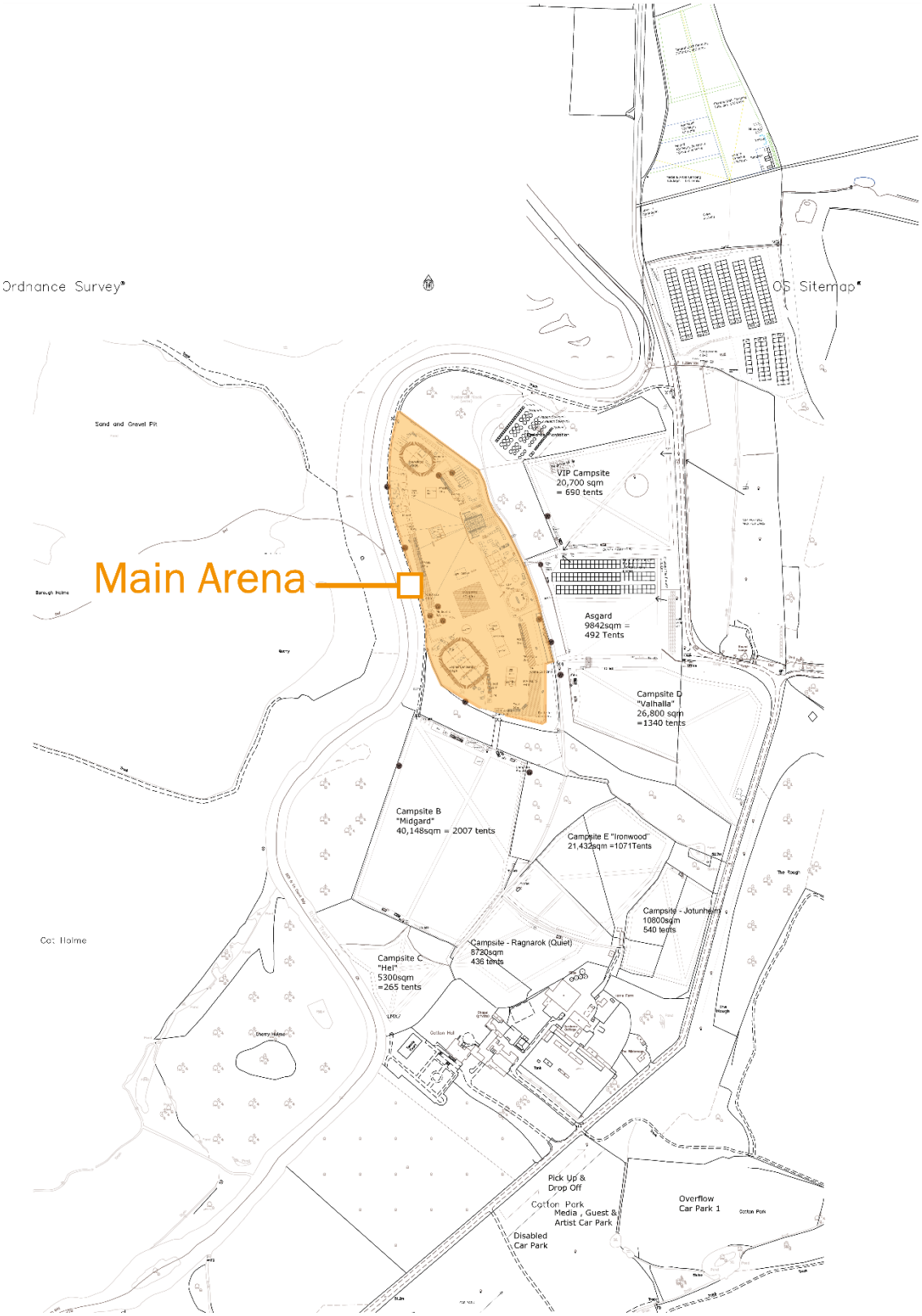
5.4.2. Plan of site

Figure 5.43 - Bloodstock Illustrated Map

Bloodstock CAD Map

The Bloodstock Site is comprised of several campsites and car parks, which surround a central main arena, which contains stages, bars, fairground attractions, sponsored areas and market traders. The location of the main arena in the context of the wider site is shown below.

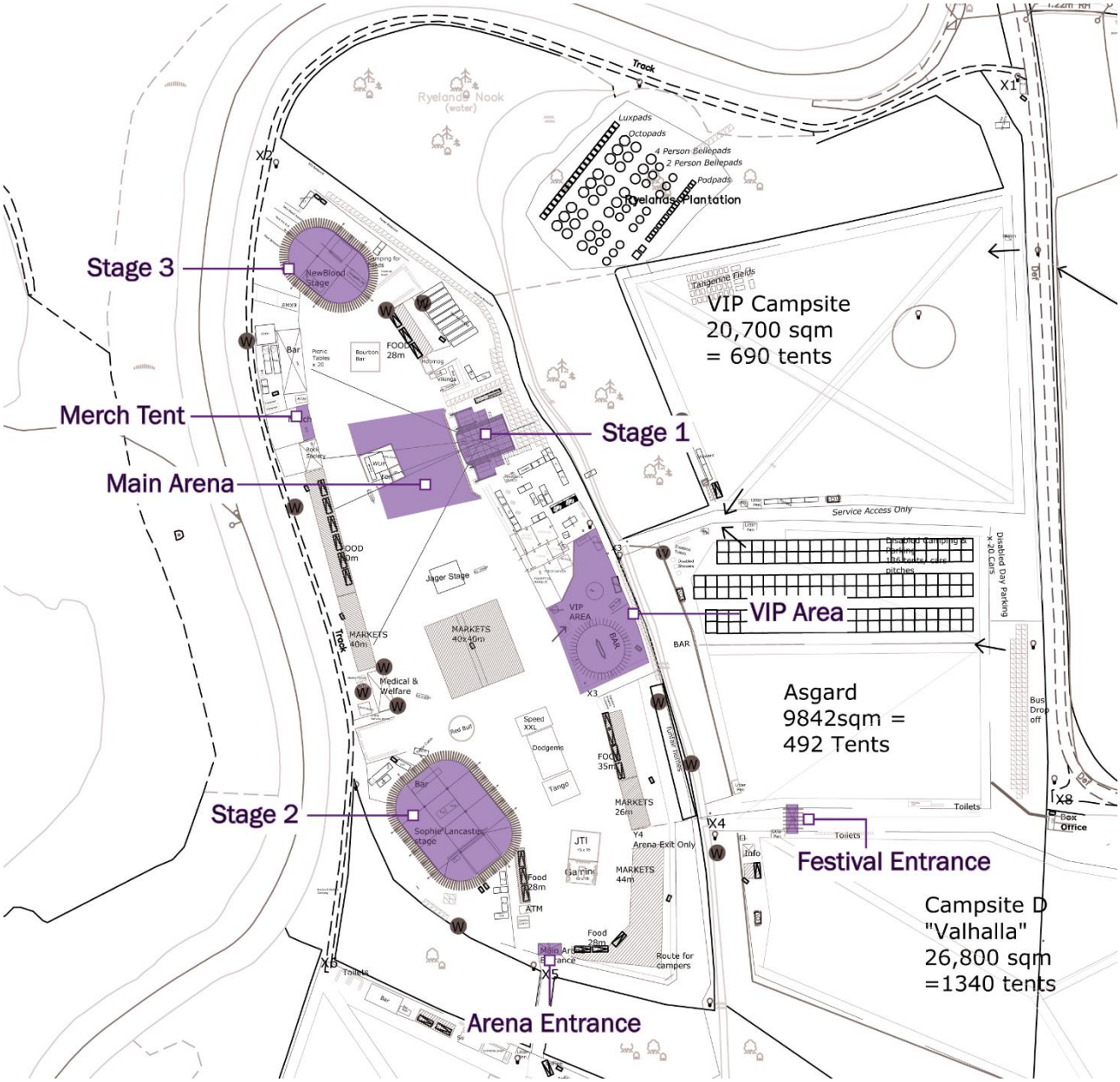
Figure 5.44 - Bloodstock CAD Map



Bloodstock Points of Interest

Key points of interest, identified as areas where recording would take place ahead of the CrowdDNA observatory, are highlighted below on a map of the main festival arena.

Figure 5.45 - Bloodstock Points of Interest

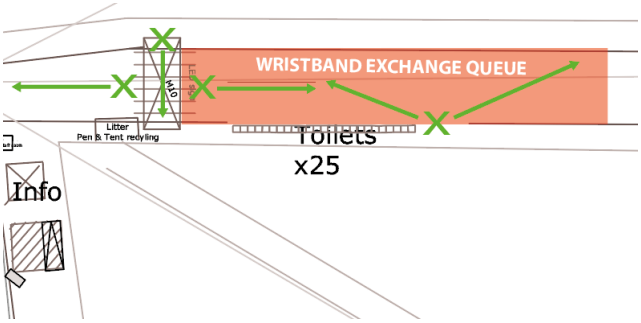


Other points of interest, which were identified whilst on-site, will be summarised in chapter 5.4.4.2 of this report, which shows all camera angles recorded from over the course of the observatory.

5.4.3. Data plan

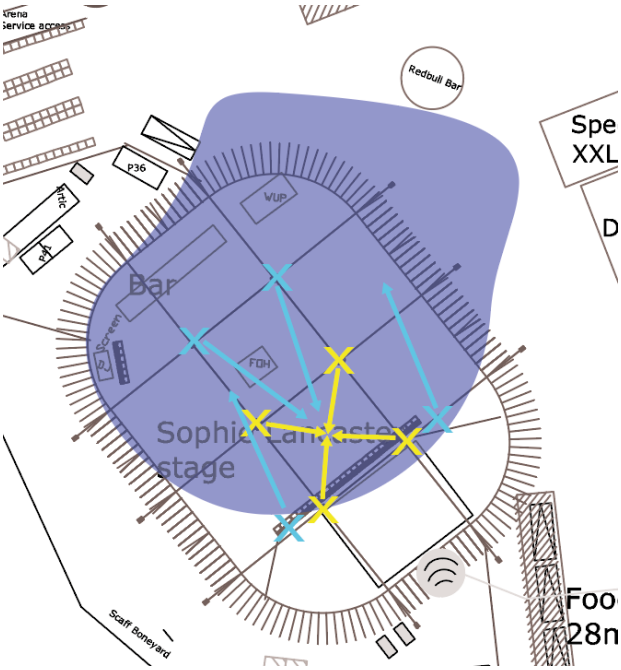
5.4.3.1. Video

Figure 5.46 - Wristband Exchange



Entry queue and wristband exchange with a focus on the crowd movement in the queue up to wristband exchange, crowd going through wristband exchange and crowd leaving wristband exchange. The movement through here is slow as people are carrying all their kit through narrow lanes. This means longer videos are required to capture the crowd movement from joining the queue to leaving wristband exchange. On leaving wristband exchange, people stop outside of the tent to reorganise themselves to carry equipment.

Figure 5.47 - Sophie Lancaster Stage



Videos capturing the stage big top marquee filling up with people from circa 15 mins before the band starts and into the first song.

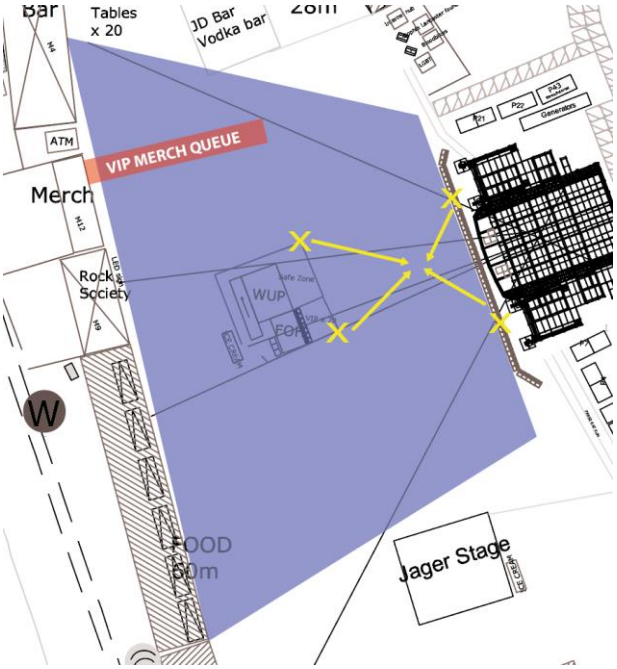
Videos capturing the stage big top marquee emptying from the last song until the marquee is predominantly empty.

Crowd movement in the pit (yellow) – positioned in front of pit barrier (after first 3 songs) or by king poles if pit access is restricted.

Figure 5.48 - VIP Area

Crowd movement and bottle-neck: high footfall areas with security check.

Figure 5.49 - Main Stage



Crowd in front of the main stage (may not able to film from inside pit barriers (accreditation dependent) if not, stand along the front of the pit barrier further out). If being infront of the stage is not viable, position yourself on the corners of Front of House and point into the crowd towards main stage. (yellow)

Observation points:

- VIP merch queue (Friday morning) and general merch queue throughout the day
- Bar next door to merch

5.4.4. Site Attendance

CrowdDNA Observatories attended the Bloodstock Open Air festival on Friday 12th July 2022. Observatories were on site between 09:00 and 01:00, in order to capture footage of both ingress and egress between campsites and the main festival arena, as well as all previously identified points of interest stated in 5.4.3.

5.4.4.1. Photos

In addition to the video footage of site walkthroughs and of crowds throughout the festival, photos were taken to provide additional context to the video locations. Photos taken are presented throughout this section.

Stage 1 Arena

Stage 1, also referred to as the Ronnie James Dio Stage, was the main stage for the headline acts at Bloodstock. Stage 1 was situated in front of the largest arena space and had a large accessible platform adjacent to the Front of House (FOH). The image below was taken from in front of the accessible platform, facing into the arena and Stage 1.

Figure 5.50 - Stage 1 Arena

Stage 1 Pit

The area between Stage 1 and the crowd barriers, generally referred to as the ‘pit’, which is primarily used by security and to allow press photographers close access to the stage, is shown below.

A raised platform was positioned between the pit and the crowd barrier directly in front of the stage. This was used by members of the security team to safely bring crowd-surfers over the barrier during performances, as well as by camera operators recording the performances on-stage.

CrowdDNA cameras were set up either side of Stage 1 in the pit for the Friday evening headline performance by Behemoth, facing out towards the center of the crowd.

Figure 5.51 - Stage 1 Pit

Figure 5.52 - Stage 1 Accessible Platform

Figure 5.53 - Stage 1 from FOH

Figure 5.54 - Merchandise Tent Queues

Figure 5.55 - Food & Beverage Vendor 2

Stage 2 Arena

Stage 2, also known as the Sophie Lancaster Stage, was situated in a large, big-top marquee close to the festival arena entrance. The area in front of the stage was much smaller than that of Stage 1 (which is outdoors), with a smaller FOH area and accessibility platform located towards the rear of the marquee. A bar was positioned to the rear of the marquee, serving both soft and alcoholic beverages.

The image below shows Stage 2 and the arena, from the FOH area to the rear.

Figure 5.56 - Stage 2 & Arena

The image below shows crowds behind the FOH, during Machine Head's performance. Crowds queueing at the bar at the rear of the marquee can be seen at the top of this image.

Figure 5.57 - Crowds behind the FOH

Stage 2 Pit

The “pit” area between Stage 2 and the crowd barriers was significantly narrower than the pit provided at the main stage.

A significantly higher number of crowd-surfers were carried over the barrier at Stage 2, compared with Stage 1, possibly due to higher crowd densities within the marquee and the band performing. Large bins full of drinking water were also positioned within the stage 2 pit, with security staff handing out cups of water and refilling bottles for audience members at the front of the crowd.

CrowdDNA cameras were set up either side of Stage 2 in the pit for key performances, facing out towards the center of the crowd.

The image below is captured from the Stage 2 pit, from stage left, showing the crowd barriers as well as security personnel in front of the barriers.

Figure 5.58 - Stage 2 Pit

Stage 2 Pinch-Point

The positioning of a circular Red Bull bar between the Stage 2 Marquee and fairground attractions in the festival arena created a pinch-point, which slowed crowd movement during busy egresses from Stage 2 at the end of performances. Crowds traversing this pinch-point can be seen in the image below.

Figure 5.59 - Stage 2 Pinch-Point

Shelter

Canvas shelters over seated areas provided shaded areas between Stage 3 and Stage 1, as shown below.

Figure 5.60 - Shelter

5.4.4.2. Video

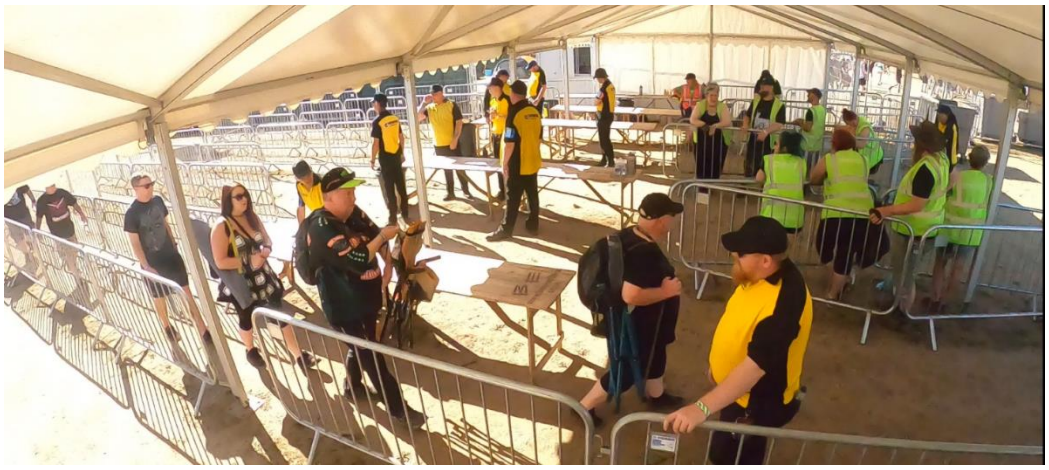
Videos were captured from vantage points throughout the site, as described in section 5.4.3 of this report. This section shows the views from each of the camera angles used, via snapshots of the video footage taken. A reference to the video file from which a capture is taken from is provided in each description.

Main Site Entrance

The main site entrance is located between the Asgard and Valhalla campsites, at the end of a long, wide, walkway. The site box office is located at the other end of the walkway, where tickets can be exchanged for wristbands.

Security checks take place at the Main Entrance before visitors enter the site to set up tents in the camping areas. The image below shows the security marquee at the main entrance, which all general admission visitors pass through on entry to the site and is taken from BS_MainEnt_1.mp4.

Figure 5.61 - Main Site Entrance

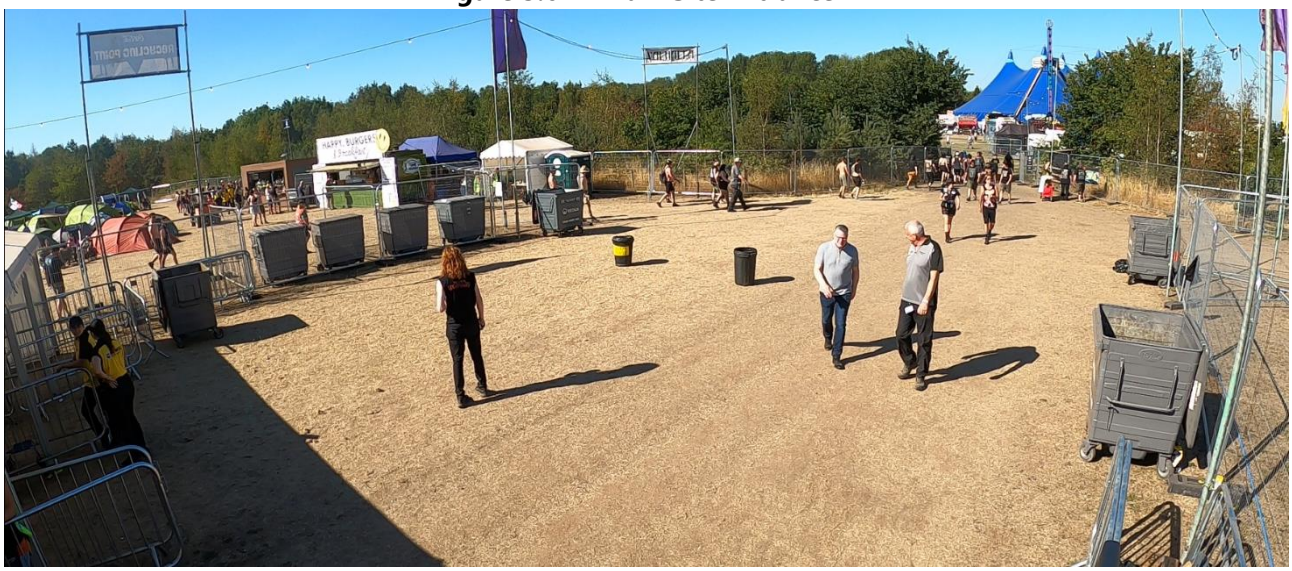


The footage from the above snapshot was captured on Friday 12th August. The footage shows a small number of visitors arriving to the site, however the majority of visitors (approximately 8,500) arrived on Thursday 11th July, where queues stretched the entire length and width of the walkway and lasted for approximately 6 hours.

Additionally, the site opened at 08:30 on Friday 12th July, 90 minutes ahead of the posted 10:00 opening time, and as such, some of the crowds had already arrived prior to recording commencing at 09:45.

Crowds were also recorded making their way into the site after passing through the main entrance, from the angle shown below from BS_Campsites_1.mp4.

Figure 5.62 - Main Site Entrance 2



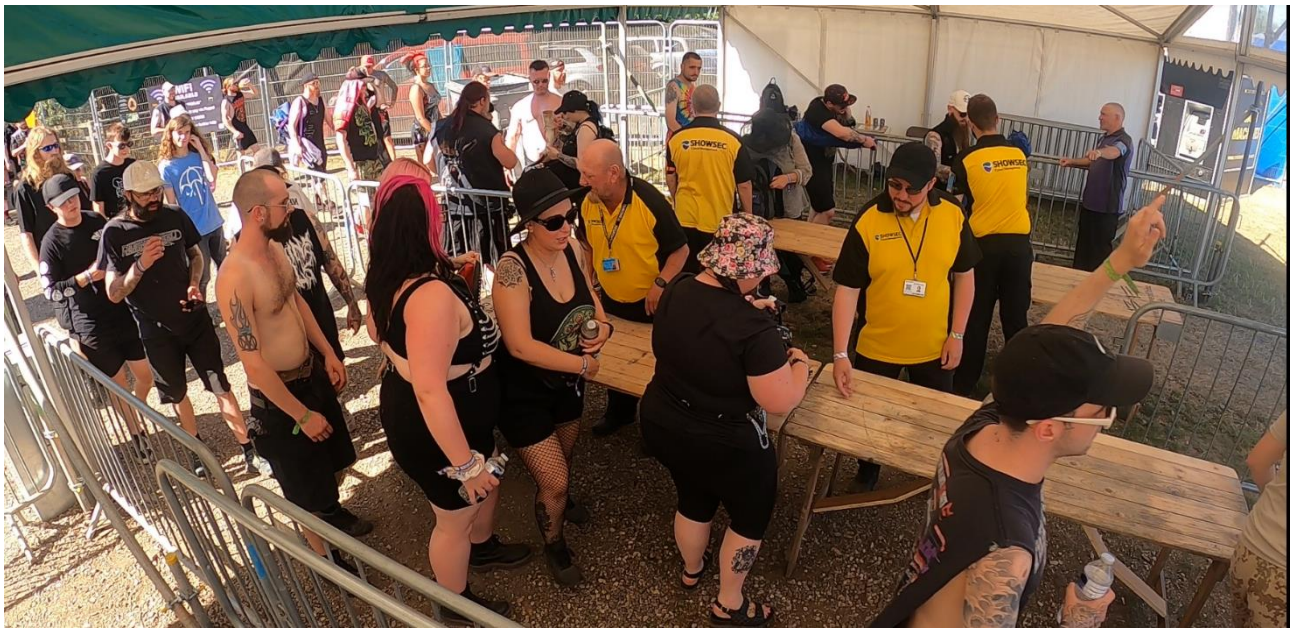
Festival Arena Entrance

A second security marquee was located at the festival arena entrance. Wristband checks and bag-searches took place at this point, predominantly to ensure that alcohol was not brought into the arena from the campsites. Any alcohol found was confiscated by security at this point.

Footage was captured both within the marquee, and of crowds entering the arena, facing away from the marquee into the festival grounds.

The image below shows the view from the arena entrance security marquee, taken from BS_Arena_BagCheck_1.mp4.

Figure 5.63 - Festival Arena Entrance



The image below shows the view from footage taken of crowds entering the festival arena, after passing through the bag check, and is taken from BS_Arena_Ingress_1.mp4.

Figure 5.64 - Festival Arena Entrance 2

Merchandise Tent Queues

Queueing at the merchandise tent was filmed during the late morning/early afternoon period, where queues were at their lengthiest. The Queue was shot from the rear of the accessible platform in front of Stage 1, facing away from the platform towards the merch tent.

The image below is taken from BS_MerchQueue_1.mp4

Figure 5.65 - Merchandise Tent Queues

Queueing was also filmed from an alternative angle, captured from the ATM machine which can be seen above, facing towards the accessible platform, as shown below in this capture from BS_Opp_MerchQ_1.mp4.

Figure 5.66 - Merchandise Tent Queues

Stage 2

Crowds at Stage 2 were recorded during the build-up and performances of Party Cannon, Machine Head, and Sleep Token, and were recorded from positions either side of the stage in the pit, facing into the crowd away from the stage, as well as from the FOH/Accessible platform at the rear of the marquee, facing towards the stage.

The below image shows the camera angle from stage-right in the pit, and is taken from BS_PartyCannon_SR_1.mp4.

Figure 5.67 - Stage 2

The below image shows the alternative camera angle from stage-left in the pit and is taken from BS_MachineHead_SL_3.mp4.

Figure 5.68 - Stage 2 2

Crowds in the above image were the largest seen on Stage 2 during the day's recording. This is due to a mystery band performing in this timeslot, which lead to large crowds building in anticipation of the performance. Machine Head, the band performing, are a well-known and popular band in the heavy rock/metal genre and would typically headline the main stage at a festival of this size.

The image below shows the camera angle used to record Stage 2 crowds from the accessible platform left of the FOH and is taken from BS_MachineHead_FOH_L_1.mp4.

Figure 5.69 - Stage 2 3

The below image shows the angle used to record crowds from the right-hand side of the FOH, facing stage 2, and is taken from BS_MachineHead_Preshow_FOH_R_1.mp4.

Figure 5.70 - Stage 2 4

Crowds for Sleep Token's headline set at the end of the day were not recorded from the FOH, as 2 of the 4 cameras we're recording site egress. Crowd and egress footage from Sleep Token was recorded from either side of the stage in the pit.

Stage 1

Crowds at Stage 1 were recorded during Behemoth's headline set, from positions either side of the stage in the pit, facing into the crowd away from the stage, as well as from the FOH/Accessible platform at the rear of the arena, facing towards the stage.

The camera angle shown below overlooks crowds at Stage 1 from stage-right in the pit, and was taken from BS_Behemoth_SR_3.mp4.

Figure 5.71 - Stage 1

The camera angle shown below overlooks crowds at Stage 1 from an alternative angle from stage-left in the pit and was taken from BS_Behemoth_SL_1.mp4.

Figure 5.72 - Stage 1 2

The above shots provide a clear picture of both the crowds, as well as of the security & press activity which typically occurs within the pit.

The camera angle shown below was filmed from the left-hand side of the accessible platform in front of Stage 1, facing the stage. Poor lighting has affected some of the footage of the crowds from this angle, though light from the stage intermittently produces clearer footage.

The image below is taken from BS_Behemoth_FOH_L_2.mp4.

Figure 5.73 - Stage 1 3

The camera angle shown below was filmed from the FOH, to the right of the accessible platform in front of Stage 1, facing the stage. As above, poor lighting has affected some of the footage of the crowds from this angle.

The image below is taken from footage of the minutes prior to the performance on Stage 1 beginning, shown in BS_Behemoth_FOH_R_1.mp4.

Figure 5.74 - Stage 1 4

Egress

Crowds egressing from the arena following the end of the headline sets on both the Stages 1 and 2 were recorded at the end of the day, from both the inside of the bag-check marquee, and from the outside of the arena, facing away towards the camping areas.

Barriers within the security marquee were removed to allow greater flow of people out of the arena. These barriers were replaced as steady numbers of people began to return to the arena from the campsites for the DJ sets, which continued in the festival arena until 03:00. Bag searches and wristband checks continued to be in operation at the security marquee, much in the same way as they were carried out during the ingress at the start of the day.

Footage of the egress from inside the security marquee was recorded at the camera angle shown below, taken from BS_Arena_Egress_3.mp4.

Figure 5.75 – Egress 1

The image below shows the camera angle used to record visitors returning to the campsites, having just left the arena, and is taken from BS_Arena_EgressToCamping_3.mp4.

Figure 5.76 – Egress 2

5.4.4.3. Site Observations

Main Entrance

- A conversation with security revealed that 8,500 visitors entered on Thursday (previous day) when most of those camping arrived and when large queues were seen, with all entry lines being used. Significant queues were present from 10:00, and didn't clear until 16:30.
- On the day of the CrowdDNA observatory, gates opened early, at 08:30 rather than 10:00, meaning any potential queues were not recorded, rather a slow, steady flow of day entry guests throughout observed period.

General

- Serious lack of shade across entire site during hot weather, with people packing into any area of shade they can find
- An insufficient number of water standpipes for refilling bottles. Only two locations within GA site identified, by stage 3 and by F+B nearest to stage 2. Both locations extremely busy throughout day. Between 1100-1200 both have long queues of approximately 30m or so, 60/70 people in each queue. However, lots of water locations provided within campsite, where no queueing was seen.
- No signage showing partnership between festival and CrowdDNA project seen anywhere on site (despite prior agreement).

Arena Egress

- Once peak had arrived low numbers were observed entering site (although some performances on until 03:00)
- Staff set up entry queue and security check again at 22:59 once consistent lower egress flow seen for some period, as numbers entering for later acts started building up again, but only gradual low flow seen with only intermittent small numbers queueing (1-4 people)
- Mass egress at 00:05 again from Sleep Token performance at stage 2, which lasted 3 minutes before egress gradually reduced and settled at a consistent lower level, but at a higher rate than before.

Machine Head (Mystery Band) Performance

- Densely packed out in tent, almost to same level as Party Cannon 30 minutes before performance.
- By the start of the performance, dense crowding was seen throughout including far back to rear of tent, even behind sound platform and in front of bar, which had been just bar queueing and circulation space during previous performance.
- Approximately at capacity inside the bog-top marquee stage structure, and around 6 people deep outside tent at entrance points with crowds impeding entry/exit.

Second Stage

- Pinch-point for circulation identified between second stage and red bull drinks tent (video/photos taken) after Machine Head, with overflowing crowds from performance impeding those moving past drinks tent.

Merch Stand

- Pinch-point between rear of merch queueing and accessible viewing platform compound. Lots of people sitting with camping chairs in key movement spaces back from stage towards and around pinch-point, restricting flow during mass egress after performance on Stage 1 ends.
- Little organisation of queue – no lane barriers in place and cashiers seemingly serving customers at random.

5.5. ArcTanGent

5.5.1. Description

ArcTanGent is an award-winning independent festival founded in 2013, which takes place in Somerset, UK every August. With a licensed capacity of 12,000, ArcTanGent attracts an international audience and line-up. Winner of the "Best Small Festival" in the UK Festival Awards, ArcTanGent curates around 135 bands, across 5 stages over 4 days. The greenfield camping festival is unique in its curation of math-rock, post-rock, noise-rock, leftfield, experimental music.

The festival stage performance times are intentionally staggered between 11:00 – 23:00 with the two arenas hosting one stage at a time with the fifth stage live at the same time as the smallest stage in the main arena.

5.5.2. Plan of site

A CAD plan of the ArcTanGent site is shown below in **Erreur ! Source du renvoi introuvable.**, with a colour site map shown in green. The festival arena is highlighted on the CAD plan in green.

Figure 5.5 - ArcTanGent CAD Site Plan

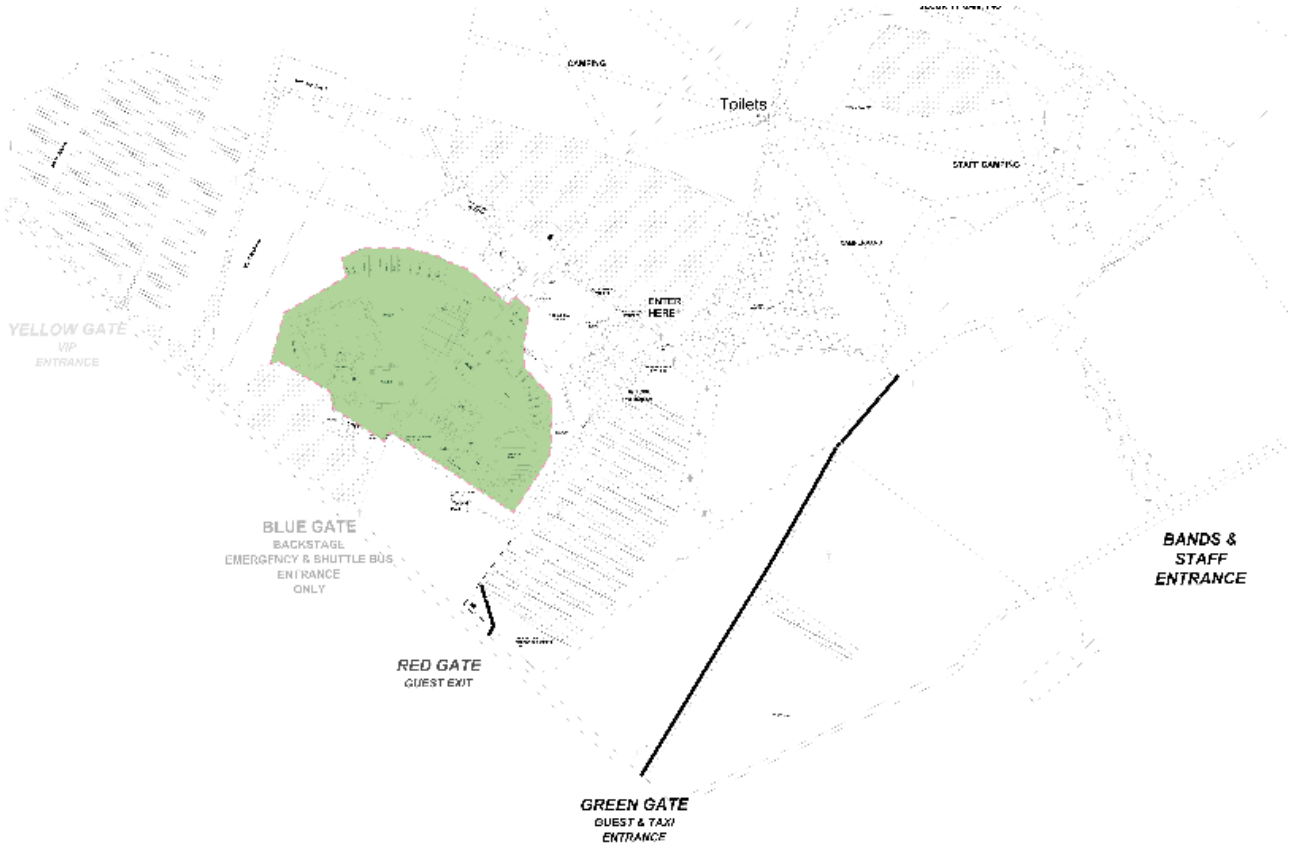


Figure 5.6 - ArcTanGent Site Map

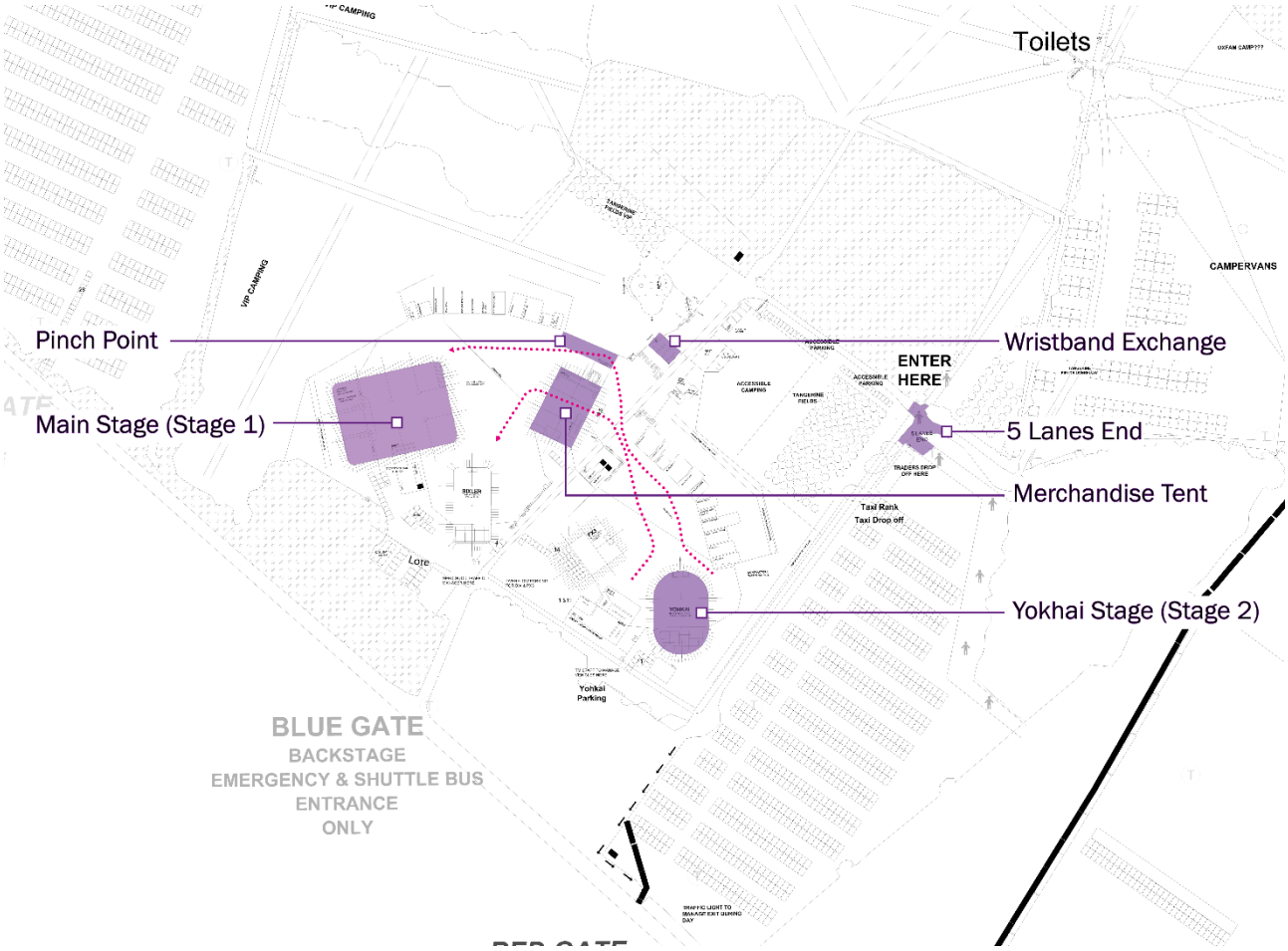
5.5.1. Data plan

5.5.1.1. Video

Filming locations

Key Locations where recording occurred as part of the CrowdDNA observatory are shown below in, with static filming locations shown in purple, and the routes of recorded site walks shown in magenta.

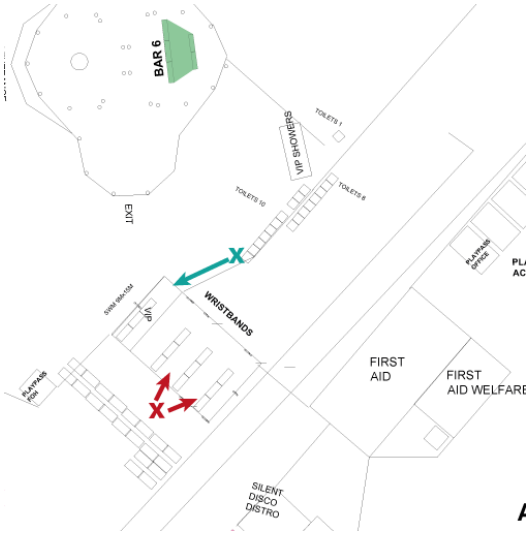
Figure 5.79 - ArcTanGent Filming Locations



Camera locations and positioning

Recording positions used at ArcTanGent are shown below on Figure 5.7 to Figure 5.11.

Figure 5.7 - Wristband Exchange

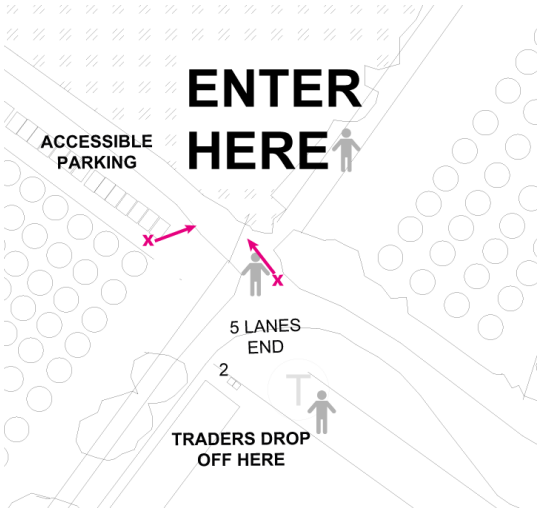


Queues for wristband exchange were recorded at the beginning of the day. People movement through wristband exchange, as well as queues beyond the security tent were recorded by 2 cameras at position 1.

The VIP Lane, separated by a fence and feeding into the arena from the VIP camping area was recorded at position 2

Queues at the ArcTanGent wristband exchange differ from the Bloodstock queues, as visitors at ATG have already camped prior to collecting wristbands, and as such are carrying little to no luggage through into the arena.

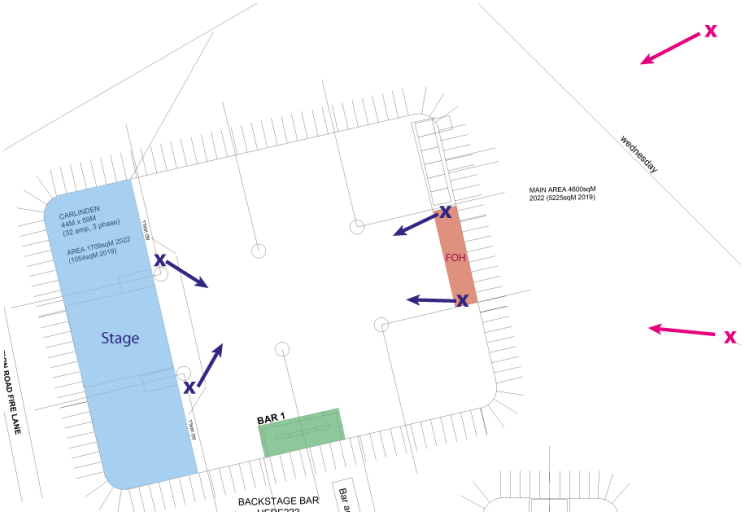
Figure 5.8 - 5 Lanes End



Two cameras were positioned to record the 'Five Lanes End' where multiple thoroughfares converge, including general car park, accessible parking/camping and production road & soft ticket check, traffic ingress and car parking, taxi drop-off, crossing of people and traffic, soft ticket check/security point, shuttle bus drop-off and consequent queues.

Observations of management all the above mentioned processes were captured during recording

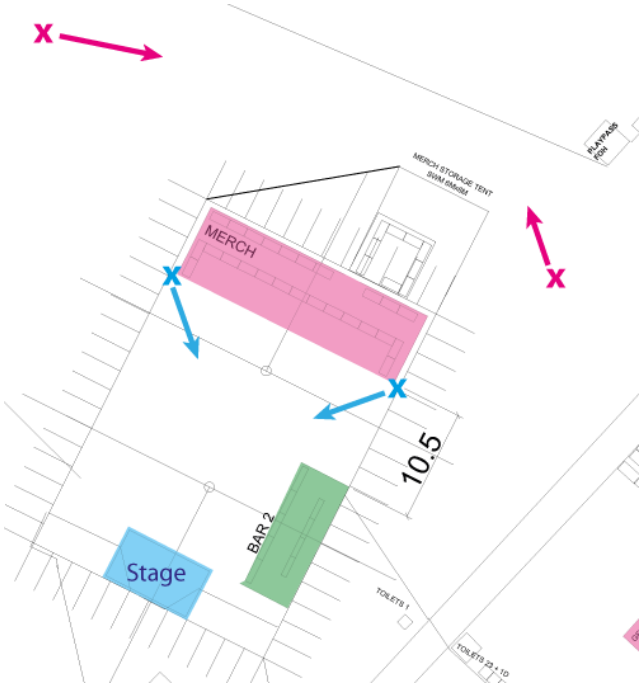
Figure 5.9 – Main Stage



Crowds in the main stage arena were recorded from two positions in the pit between the stage and the crowd barriers, as well as from two positions in the front-of-house to the rear of the marquee.

Egress from the main stage at the end of performances was recorded from two positions outside of the marquee.

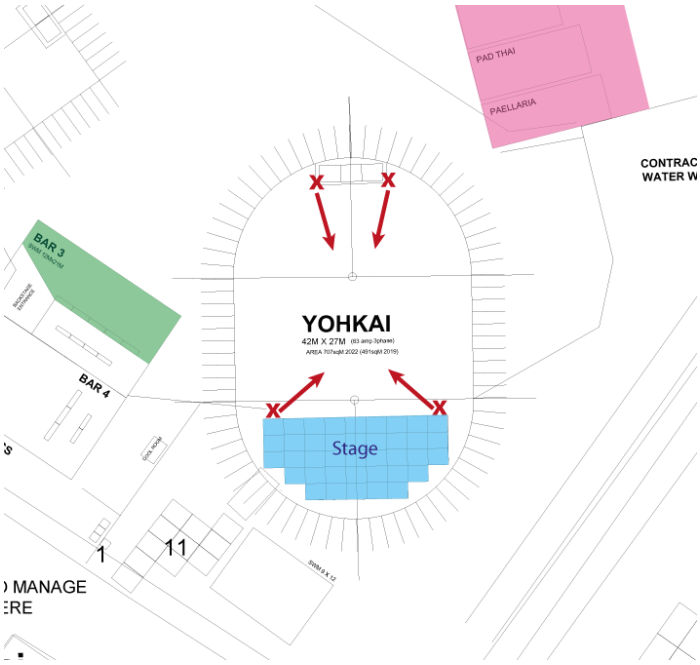
Figure 5.10 – Merchandise Tent



Stage 5, as well as a bar, and the festival merchandise stall were all contained within an open-sided marquee, which also acted as a through-route through the festival site. Crowds queueing for merchandise and passing through the tent were recorded from 2 positions to either side of the merch stall.

A pinch-point between the merchandise tent and the arena perimeter fence was also recorded from two positions, either side of the tent.

Figure 5.11 - Yokhai Stage (Stage 2)



Performances on Stage 2, known as the Yokhai Stage, were recorded from two positions in the pit between the stage and the crowd barriers, as well as from two positions in the front-of-house to the rear of the marquee.

5.5.1. Site Attendance

5.5.1.1. Photos

In addition to the video footage of site walkthroughs and of crowds throughout the festival, photos were taken to provide additional context to the video locations. Photos taken are presented throughout this section.

Figure 5.1 - Main Stage from Pit, Stage Left

Wristband Exchange

The wristband exchange queue moved quickly due to the festival goers being allowed to pitch their tents prior to receiving their wristbands and entering the arena. This meant that people were not trying to carry tents, bags, drinks etc. through the wristband exchange. Peak time were experienced just before the bands started and in line with coach drop-offs for day ticket holders (people not camping).

The VIP queue experienced a short wait time at key times in the day, slowed down by the distribution of merchandise as one of the ticket holder benefits.

Figure 5.86 – Wristband Exchange

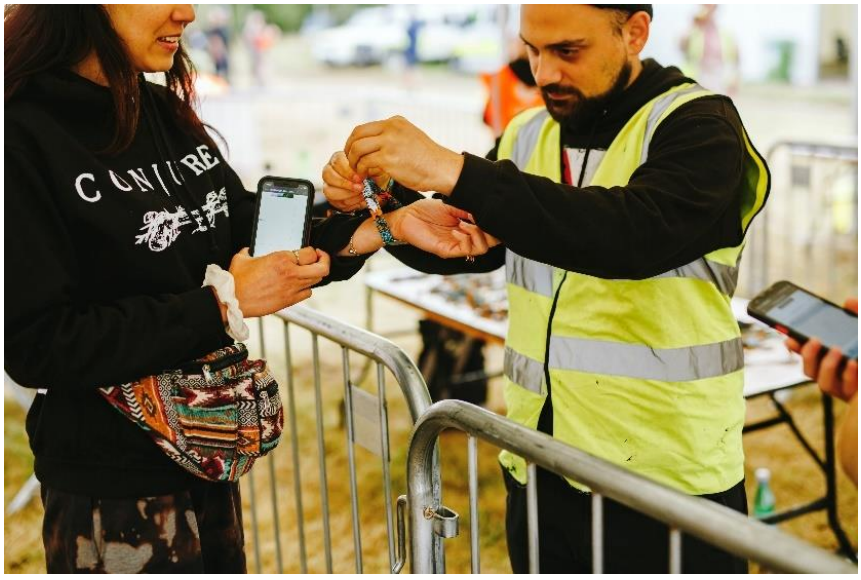


Photo credit: Derek Bremner © 2022 **NOT FOR PUBLICATION**

Elephant in the Room stage & Yokhai Stage

Looking towards the Elephant in the Bar Room stage (with the main stage to the right) the pinch point is on the left-hand side of the big top marquee. Due to the walk-way through the big top marquee and it being the shortest route, the pinch point was never overly congested and crowd flow remained fluid.

Figure 5.87 - Elephant in the Bar Room Exterior

Sufficient space outside of the Yohkai stage and PX3 stage allowed for crowd movement to be fluid. At the end of a band's performance slot, people generally all headed in the same direction to go to one of the other stages meaning very few people were walking against the flow of the crowd, and if they were, sufficient space was available for their journey to remind unhindered.

Figure 5.88 - Stage 2 (Yokhai) Exterior

Figure 5.89 - Yohkai Audience (Maybeshewill)

Photo credit: Joseph Singh Snaprockandpop © 2022 **NOT FOR PUBLICATION**

Photo credit: Joseph Singh Snaprockandpop © 2022 **NOT FOR PUBLICATION**

Similarly, to the main stage, the structure was large enough to hold a substantial audience with plenty of space outside for the audience to stand and see the stage. For one of the most significant bands of the weekend, Maybeshewill, the crowd filled the big top marquee, but comfort levels were maintained as illustrated here in the photo of the stage from front of house. The crowd was more congested towards the front and middle of the stage which is to be expected. This band experienced some crowd surfers but at manageable levels for security.

5.5.1.2. Video

Videos were captured from vantage points throughout the site, as described in section 5.5.3 of this report. This section shows the views from each of the camera angles used, via snapshots of the video footage taken. A reference to the video file from which a capture is taken from is provided in each description.

Wristband Exchange

The wristband exchange, situated at the entrance to the main festival arena, was recorded from the two vantage points shown in Figure 5.90 -Video Location and **Erreur ! Source du renvoi introuvable.** below; in the security tent facing towards the queue, and from the VIP campsite, facing towards the VIP queue from the rear.

Figure 5.90 -Video Location - Wristband Exchange, Captured from Inside Security Marquee

Figure 5.91 -Video Location - Security Marquee, from VIP Camping Area

Five-Lanes End

Footage at 'Five Lanes End', where several footpaths as well as vehicular routes through the site converge, was captured at the 2 camera angles shown below.

Figure 5.92 -Video Location - Camera Positions at Five Lanes End

Pinch Point

The positioning of the festival arena perimeter wall and the merchandise tent created a pinch point for visitors making their way through the arena. The pinch point was filmed from vantage points both facing the merchandise tent and positioned at the northern perimeter of the merchandise tent, shown below in **Erreur ! Source du renvoi introuvable.** and **Erreur ! Source du renvoi introuvable.** as well as in section 5.5.2 of this report.

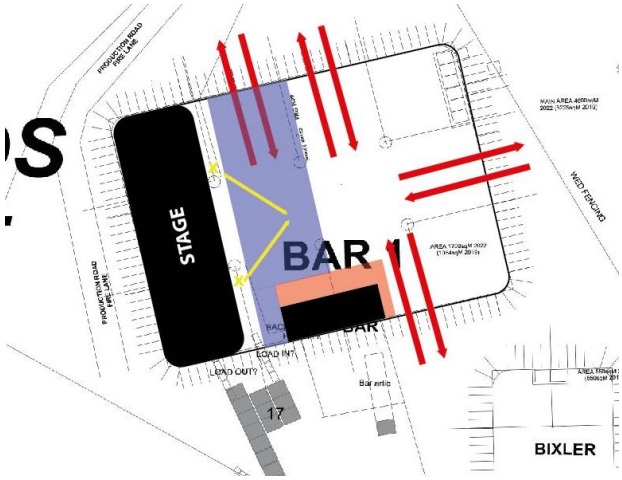
Figure 5.93 -Video Location – Pinch-point from Opposite Merchandise Tent

Figure 5.94 -Video Location - Pinch-point from Edge of Merchandise Tent

Main Stage

The main stage structure was large enough to hold circa. 8,000 people with plenty of space outside for the audience to stand and still see the stage. For the headliner, Opeth, the crowd filled the big top marquee but comfort levels were maintained as illustrated here in the photo of the stage from front of house. The crowd was more congested towards the front and middle of the stage.

Figure 5.95 - Main stage and Bar



Crowd from the pit during band performances. Stage emptying and filling up. Dwell area in front of stage. Bar queue and dwell area.

Photo credit: Johnathan Dadds © 2022 **NOT FOR PUBLICATION**

Crowds at Stage 1 were recorded from positions either side of the stage in the pit, facing into the crowd away from the stage, as well as from the FOH/Accessible platform at the rear of the arena, facing towards the stage.

Erreur ! Source du renvoi introuvable. and (Right) Video Location 5.2 below show the views from the cameras positioned in the pit between the crowd barriers and the stage, to both the left and right of the main stage. The camera positioned at stage-right of the pit captured crowds viewing the performances on stage, as well as queueing at the bar located inside the marquee.

Figure 5.96 -Video Location – (Left) ArcTanGent Main Stage from Pit Stage Left; (Right) Video Location 5.2 - ArcTanGent Main Stage from Pit Stage Right

Erreur ! Source du renvoi introuvable. and **Erreur ! Source du renvoi introuvable.**show the views from the cameras positioned in the Stage 1 Front of House, to the rear of the Stage 1 marquee.

Figure 5.97 -Video Location – (Left) ArcTanGent Main Stage from Left of Front of House; (Right) ArcTanGent Main Stage from Right of Front of House

Footage of crowds egressing the main stage were also taken the position shown below in Figure 5.98.

Figure 5.98 -Video Location – Outside Main Stage Marquee

Yokhai Stage

Crowds at stage 2, better known as the Yokhai Stage, were recorded from positions either side of the stage in the pit, facing into the crowd away from the stage, as well as from the FOH/Accessible platform at the rear of the arena, facing towards the stage.
Erreur ! Source du renvoi introuvable. and Video Location 5.3 below show the views from the cameras positioned in the pit between the crowd barriers and the stage, to both the left and right of the main stage.

Figure 5.99 -Video Location – (Left) Yokhai Stage from Pit, Stage Left; (Right) Video Location 5.3 - Yokhai Stage from Pit, Stage Right

The images below show the view of crowds recorded from the Front of House to the rear of the Yokhai Stage arena.

Figure 5.100 -Video Location – Yokhai Stage from Front of House

Figure 5.101 -Video Location – Yokhai Stage from Front of House

Merchandise Tent (Elephant in the Bar Room)

The official festival merchandise stall was situated in the Elephant in the Bar Room, alongside a bar, and Stage 5. Additionally, as the marquee was open-sided, the Merchandise Tent acted as a through route through the festival site, offering an alternative route to the previously mentioned pinch-point.

Crowds were recorded both inside the merchandise tent, from positions either side of the merchandise stall, as well as from the exterior of the tent, within the festival arena.

The view from the camera positioned outside the merchandise tent is shown below in **Erreur ! Source du renvoi introuvable.**, with the angle used to record crowds using the marquee as a through-route shown in

Figure 5.102 -Video Location – (Left) Elephant in the Bar Room Exterior; (Right) Video Location 5.4 - Elephant in the Bar Room Through-route

The views from the cameras set up by the merchandise stall, facing stage 5 within the Elephant in the Bar Room are shown below in **Erreur ! Source du renvoi introuvable.** and **Erreur ! Source du renvoi introuvable.**.

Figure 5.103 -Video Location – Elephant in the Bar Room, from Right of Merch Stall

Figure 5.104 -Video Location – Elephant in the Bar Room, from Left of Merch Stall

Figure 5.105 - Stage 2 (Yohkai) Outside

Sufficient space outside of the Yohkai stage and PX3 stage for crowd movement to be fluid. At the end of a band's performance slot, people generally all headed in the same direction to go to one of the other stages meaning very few people were walking against the flow of the crowd, and if they were, sufficient space was available for their journey to remind unhindered.

Figure 5.106 - Yohkai Audience (Maybeshewill)

Photo credit: Joseph Singh Snaprockandpop © 2022 **NOT FOR PUBLICATION**

Photo credit: Joseph Singh Snaprockandpop © 2022 **NOT FOR PUBLICATION**

Similarly to the main stage, the structure was large enough to hold a substantial audience with plenty of space outside for the audience to stand and see the stage. For one of the most significant bands of the weekend, Maybesheweill, the crowd filled the big top marquee but comfort levels were maintained as illustrated here in the photo of the stage from front of house. The crowd was more congested towards the front and middle of the stage which is to be expected. This band experienced some crowd surfers but at manageable levels for security.

5.5.4.3 Site Observations

5 Lanes End

- Required constant traffic and people management – managed with a big team of security, stewards and traffic management staff.

Wristband Exchange

- Experienced a few short queues which movement relatively quickly.

General

- Signage about CrowdDNA involvement displayed in several locations around key points including wristband exchange and cashless top up stations.
- Busy site but enough space for crowd movement throughout.

Arena Egress

- Due to the bar staying open later than the performances and the silent disco starting at 23:00 there was not a mass exodus from the arenas into the campsite.

Pinch-Point

- Due to the walk-way through the Elephant in the Bar Room stage, the pinch-point remained free of congestion.

Merch Stand

- Due to the wide layout of the merch tent, queue length did not get too long and consequently did not obstruct the walk-way through the Elephant in the Bar Room.
- Quick turn over of sales due to the cashless payment system.
- No lane barriers in place but didn't seem to be required.

6. Concluding Remarks

A range of data was collected across four festivals, one in France (Hellfest) and three in the UK (Tramlines, Bloodstock and ArcTanGent). The data captured included Xsens suits, video, photography, and general observation. From the data captured, CrowdDNA can analyse crowd movement within a festival observatory in order to better understand the forces under which crowds are exerted, the flow of the crowds and how the temporary environment influences movement. From these learnings, advice can be given to the observatories to increase crowd safety and a detailed data set can be obtained from processing the video content and Xsens data. This set of observatories also provided learning to the project team on how better to capture data at observatories in the future.

By way of summary:

- Each of the festivals whilst similar in their outdoor, multi-day format differed significantly due to demographic, curation, and participation levels. This has created unique data sets for comparison.
- There is no measurable way to conclude on how crowd movement is affected/changed by the influence of alcohol which it is assumed many partake in at the festivals.
- UK Festivals: The data captured is in shorter lengths due to battery life and the requirement to be mobile around the site. For 2023 and beyond, filming an entire day in each location would provide interesting data sets. However, this poses further production and logistics requirements, as well as expense.
- Attending the festival observatories in 2023 and beyond with increased kit and further direction on content to be captured would help to create a more in-depth data set.
- Returning to each of the observatories for the duration of the project (if viable) would provide an opportunity to compare data year on year, and further into the project, apply some of the learnings in a real-time environment.