Innovative thinking

Crowd Safety and Risk Analysis
for
South Yorkshire Police

Date: 30th May 2019
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Introduction

This document seeks to set out a number of findings and recommendations in relation to aspects of crowd dynamics, crowd safety at Hillsborough Stadium, Sheffield and its environs on behalf of South Yorkshire Police.

It examines aspects found from a number of work streams, detailed from a post event crowd analysis of the SWFC v SUFC on Monday 4th March 2019, and the resulting study conducted at a fixture during a site visit on Saturday 6th April 2019.

SWFC v SUFC 04/03/19

On Monday the 4th of March 2019, a football fixture between Sheffield Wednesday FC and Sheffield United FC took place at Hillsborough Stadium. The fixture took place in the evening, with a K.O. at 19:45hrs. The recorded official attendance was 31,630 spectators, with 3,951 of the total recorded as away spectators (SUFC).

Post-match a number of issues were raised to authorities following incidents of crowd disorder and crowd flow issues, particularly on egress from the stadium at the North Stand and West Stand exits.

The subsequent section looks at the areas highlighted as areas of concern and flashpoints.

The following material has been presented by South Yorkshire Police to assist in the review of the fixture.

- DVD 1 - NPAS
- DVD 2 – EGT compilation
Coach location

Figs 1 and 2 are stills captured from NPAS video footage pre-match in the build up to the kick off. A number of away coaches are “stacked” along Leppings Lane; at various points, double stacked. These areas are highlighted in the stills.
The coaches have clearly been placed at this location to assist the unloading and loading of away fans towards the West Stand, in close proximity to prevent the potential for disorder when fans from both sides are ingressing and egressing.

As with most risk factors and decision making though, this leaves some residual risk but also creates another risk in itself from a crowd flow perspective.

Using the footage obtained, Fig 3 has been created using a “first cut” perspective to highlight the new risks this particular coach stacking causes.

![Diagram with annotations](image)

The relevant key dimensions are highlighted on the diagram with the yellow line depicting the coach stacking operation. Ordinarily, along Leppings Lane, the egress width travelling up in a southerly direction is 17 metres (Point B) providing a flow rate of around 1,400 people per minute able to travel through the highlighted blue line. This figure is obtained by using the standard flow rate of 82 people per metre per minute able to pass through a given point. The width obtained is 17 metres, hence the figure calculated as 1,400 people per min (17x82).

With the coaches stacked during this fixture in this manner the “new” egress width along the initial point is now around 8 metres (Point C). This figure has been calculated by adding the double width of coaches, totalling 5 metres (average width of a UK coach specified as 2.5 metres), the width between the coaches, 1 metre and the loss of the pavement (2-3 metres) as an effective egress point. The pavement beyond the coaches has been discounted as this cannot be seen by fans egressing and is not a suitable egress area (future photographs/stills highlight this point).

Using Point C, 8 metre width line, the available flow rate is now around 656 ppm; a clear reduction in flow, with potential knock on effects towards the egress gates. By using this particular method and location of stacking coaches along this key egress route, results in a reduction of over half the normal egress width, causing a significant reduction in the ability to move fans clear of this area.
It is important to also note that these measurements do not include provisions or reductions of additional obstructions such as street furniture or the additions of police resources in the area and along the route. These additional points can significantly reduce the widths on Points A and C.

**Egress of Home and Away fans**

Further analysis of the footage, particularly the EGT footage, provided clear incidents and areas of poor fan behaviour and low level disorder post match.

The following section highlights key points to consider and the effects of both home and away fans “mixing”, in a chronological order over a number of minutes taken from stills of the footage provided.

The initial Figure in this section, Fig 4, highlights the concerns covered in the previous “Coach location” segment.

![Fig 4](image)

Although not the best quality, it provides an initial overview of the start of the egress post-match. As can be seen there is an initial higher density around the coaches restricting the flow up Leppings Lane towards the nearest Tram Station. Both home and away fans can be seen mixing together and already tensions are further increased.

The picture also highlights a number of points; particularly the small width now created along Leppings Lane (visual point of the street lamp left of centre towards the first coach right of centre) and the overall poor visibility during the hours of darkness in the area.

Fig’s 5 – 11 provides a visual representation and explanation of the crowd occurrences and the relevant knock on effects, highlighting key areas of concern in the process. These are taken from CCTV footage provided and time stamped from 21:41 to 21:50, thus covering the crucial 9 minutes of egress.
From Fig 5 it is clear to see that a necessary segregation line along with barriers are in place to separate the egress of both home and away fans. By referencing Fig 3 to what is seen on this image it is apparent there is no obvious area to create a sterile area or zone within the vicinity, highlighting the need and importance of an effective segregation line of police officers and barriers. From observing the footage at this point and from a physical site visit (covered later in the document) it is clear that a large proportion of home fans exit from the North Stand at Point E (highlighted in blue in Fig 5) and walk in a southerly direction up Leppings Lane, towards the Tram station.

It has already been detailed in the previous section around the reduction in egress on Leppings Lane affecting crowd flow and now in Fig 5 it can be seen that a large proportion of home fans use this particular route, with the smaller proportion of home fans walking towards Point D to leave the footprint. Upon speaking with SWFC staff it is estimated that around 50% of the total North Stand exit the ground in this direction; therefore, using these figures this could reach 5,000 persons.
Around a minute and a half later, at 21:43:03, Fig 6 shows the “start” of the disorder with a break in the police segregation line, concentrating on a particular group of home fans. The result of this is a change in direction of the away fans walking up Leppings Lane and on to the coaches, with a new focus on the home fans. This causes the crowd flow to a near stop at Points A and C (Fig 3) but a continued egress from the home fans at Point E (Fig 3), resulting in a denser crowd at both the home and away egress areas.

There is now a significant “dwell” time for the away fans as they now turn and face the home fans with tensions increased.

Fig 7 provides a screenshot at 21:43:50, under a minute later, of the new crowd dynamic caused by the increase in tension and both fans reaction and behaviour.

(Fig 7)

With the clear reduction in crowd flow away from the ground both sides of the segregation lines are clearly denser, with people stood watching, people involved in disorder or people “holding back” not appearing to want to be involved.

The large proportion of home fans needing to walk up Leppings Lane increases in density as well, resulting in a larger crossflow of home and away fans away from the ground.

It is also important to highlight the bin and bollards, seen in Fig 7, at this point as these are the types of obstacles previously detailed that can affect egress width and cause a problem with people walking in to them and falling over, with potentially serious consequences.
At 21:45:37, Fig 8 highlights the build-up of the crowd in the immediate egress points, both in the home and away sections.

The home crowd in particular are unable to move towards the Leppings Lane area in a Southerly direction towards the tram station due to the dense crowd highlighted in red and the seat of the disorder.

(Fig 8)

From the away section there is a clear “jostling” for a view and a typical crowd behaviour of the need for information and enquiry as to what is occurring. Due to a lack of crowd flow and the addition of poor behaviour it is clear to see a number of Sheffield United fans locate themselves near to the barrier and take part in verbal altercations with the Sheffield Wednesday fans. At points along the segregation line the barrier system is severely tested when certain fans attempt to break it.
Fig 9, timed at 21:46:53, is used and included here to highlight how quickly the crowd has built up and how at this stage the integrity of the barrier system and safety of the police and general fans is at its most vulnerable.

This screenshot is taken just over a minute later than Fig 9, but already the home fans are closer to the segregation line and larger in both numbers and density. Again this is clearly caused by the lack of crowd flow away from the ground and more fans leaving the ground in to this particular area.

Because the crowds have not been able to leave the area as normal the fans from both sides begin to migrate to the barrier segregation further back in the system and exchange verbal’s, again increasing tension.

Fig 10, timed at 21:48:21, is taken just a minute and a half later after Fig 9 but visually emphasises the “knock-on effect” of the lack of crowd flow. It can be seen that there are still a number of fans inside the ground (highlighted blue), leaving to the outside away area.
All the events over the previous 3-4 minutes has created a denser build up and slow to non-existent crowd flow to the point that the away fans are now up to the entrance gates.

Finally, Fig 11, timed at 21:49:59 shows the away area to be at its peak density throughout any time during post-match egress. As discussed this is due to the lack of effective flow caused in the main by the aforementioned aggravating factors.

There is now a great potential for crowds to become nervous, unsure of what is happening and react in a negative way as a collective towards police, stewards or the barrier system.

A number of fans have been stood in this area for a significant period of time with tensions, frustrations and a lack of information, other than potential rumour, as to why they are not able to leave.

**Conclusion - SWFC v SUFC 04/03/19**

A large weight can be placed on poor fan behaviour and the additional tension and crowd reactions found at local derbies, to the areas and figures highlighted in this section, but other factors discussed here play a significant part in the events seen.

It has been detailed about the location of the coaches and the effect it has had on the crowd flow and this should be not underestimated but other factors need to be considered. Two of the main points under consideration need to be looked at; namely the potential for a “Holdback” of away fans to prevent both teams leaving at the same time, but also the change in egress direction for the home fans leaving the North Stand.

These points will be addressed in the following sections of this document.
Home Egress from the North and Away Egress from the West Stand

The following section discusses the egress post match by home fans of SWFC, specifically from the North Stand and by away fans in general, from the West Stand. It includes references from the previous sections but looks to incorporate and build on findings from a physical site visit conducted on Saturday 6th April 2019, during the SWFC v AVFC fixture. This site visit was conducted by Ben Cowcill, Crowd Science, Manchester Metropolitan University.

Currently the North stand is occupied by the “home fans” and the West stand by the “away fans”.

Fig 12 highlights the key egress areas and directions for the two stands.

As can be seen, home fans can egress from the North stand towards both the East and West sides of the ground. Away fans egress from the single area within the West stand. Due to this type of egress both home and away fans meet at a crucial area in the system, Leppings Lane area. This has previously been discussed and highlighted as an area of concern in terms of a flashpoint and a concern from a crowd flow perspective and can be further highlighted in Figs 13 and 14.
From this both home and away fans are seen “mixing” at a vital part in the egress system. Along with fans moving and flowing in a number of directions, whether towards the tram network or towards the away coach area, a number of fans remain static waiting for friends/family or standing in small groups. Also apparent is the number of police resources needed to monitor the crowd and minimise any disorder or incidents. The number required during the aforementioned derby fixture would also see a large increase of necessary police resources.
During this particular egress a number of flash points occurred; Fig 15 showing a number of rival fans engaging in a heated argument, with police resources needed to intervene and prevent any escalation. Coupled with the footage from the derby fixture this appears to be a potentially common theme and risk.

(Fig 15)

With this incident occurring, crowd flow and dynamics are adversely affected with other fans “holding back” and slowing their walking speed and others changing direction to avoid the conflict. This has a knock-on effect with the remaining crowd egressing much slower and can cause a denser crowd build up towards the stadium exit points, as previously highlighted.

A consideration, therefore, would be to continue egressing the away crowd as is now, but to egress the home crowd in one direction towards the East of the stadium. Fig 16 explains the basic crowd flow.

(Fig 16)
Before further analysis and consideration takes place for this option, a proposal to SWFC and an agreement to trial the new form of egress would be needed.

The current egress from the North Stand towards the East side would naturally become larger and take longer but options of increased areas around carriageways, exit routes could be incorporated.

It is important to confirm at this stage that evacuation procedures from this particular stand would remain extant and the home crowd would evacuate from either side as is now.

With the North Stand crowd egressing towards the East of the stadium this would have many positive benefits from a crowd dynamic, crowd flow perspective at the West of the stadium.

As discussed the key area of risk and threat is around the away fan egress towards Leppings Lane. By removing the home fans egress point and reducing the footfall in this area a number of key areas are improved.

The North Stand currently holds, or has capacity to hold, around 10,000 spectators. As mentioned, SWFC staff anticipate and estimate that around 50% of this stand egresses to the West. By removing a footfall in the area by potentially 5,000 fans the area is immediately easier to manage.

**Cross Over and Cross Flow**

By egressing the home fans in a separate direction and area this eradicates the potential for any cross over or cross flow of rival fans. Away fans visiting the ground will egress in to a typically sterile area, thus minimizing the risk of home fans being in the vicinity.

Scenes described and detailed earlier in the two match day analyses should be minimised or eradicated should this option of a single away egress area be confirmed.

**Available Holding Space**

As observed through the footage and via the site visit the current “outside” space where away fans egress is not sufficient to “hold” away fans, in its current layout, should it be necessary to under circumstances.

Fig 17 provides a “rough cut” current total area space of the current layout due to the home and away egress and the current segregation set up.
As can be seen the total area available is approximately 765m² resulting in crowd figures at the various densities as follows.

<table>
<thead>
<tr>
<th>Density</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 person per metre²</td>
<td>765 persons</td>
</tr>
<tr>
<td>2 persons per metre²</td>
<td>1530 persons</td>
</tr>
<tr>
<td>3 persons per metre²</td>
<td>2295 persons</td>
</tr>
<tr>
<td>4 persons per metres²</td>
<td>3060 persons</td>
</tr>
</tbody>
</table>

By changing the egress route for the home fans, the available space accessible to away fans and a place where, if necessary, a crowd can be held for safety reasons, increases to the available area seen in Fig 18.
As can be seen the total area now available is approximately 1330m² resulting in crowd figures at the various densities as follows.

<table>
<thead>
<tr>
<th>Density</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 person per metre²</td>
<td>1330 persons</td>
</tr>
<tr>
<td>2 persons per metre²</td>
<td>2660 persons</td>
</tr>
<tr>
<td>3 persons per metre²</td>
<td>3990 persons</td>
</tr>
<tr>
<td>4 persons per metres²</td>
<td>5320 persons</td>
</tr>
</tbody>
</table>

These new figures highlight a key increase in a safe capacity for the area.

The crowd densities and numbers highlighted in these two examples are based on and taken from Prof. Keith Still’s “Crowd Density V Crowd Flow rate” chart. Fig 19 provides an overview of this and highlights low risk and high risk capacities and figures.
As shown in Fig 19 from a crowd density perspective alone and calculated in the two areas, at 1 person per m² and 2 persons per m² the crowd is in a stable position and format. By looking at the crowd, and by providing the total figures, at 3 persons per m² the area and crowd is at capacity, hence the turn from green to amber. This is where a crowd is at its safe limit and maximum, and where upon the crowd moving is at its peak flow of 82 people per metre per minute. By including the figures at 4 persons per m² it is clear to note that the area and crowd is no longer stable and is moving towards being of an unstable nature, hence the red rating.

These figures and chart have been included to use as a reliable reference when considering a crowd “hold” in this area; for example, if the away crowd is 3,000 in total then in Fig 17’s layout the crowd will be over capacity if held in this area alone, but at safe density in Fig 18’s layout.

This format can be considered when it is felt necessary to hold an away crowd in either layout.
Location of “Away” Coach park

Should the analysis and acceptance of the change in home egress and layout prove viable then it would naturally create the ability to change a number of resource/vehicle deployments and overlays, reducing resources significantly in key areas.

One such change could be to the location of the “away” coach park. Fig 20 provides the current route taken by the away fans towards the coach park.

(Fig 20)

The current route is 650m in length, moving from the ground, passing by a large number of houses and then towards a major traffic junction. A quick first cut analysis suggests that at an average walking speed of 1.4m per second it will take a person around 8 minutes to walk the journey.

During high profile and contentious fixtures, where the away team brings a large number of coaches, this could prove another area of potential conflict/disorder needing a large number of police resources.

With the absence of home crowds being present in this area it may provide less potential problems in this particular area and route.

Fig 21 provides an additional option where the coaches could be moved closer and “stacked” close by; thus reducing the need for a large number of away fans moving through the community and reducing conflict. This type of coach stacking was evident at the SWFC v SUFC fixture but proved problematic due to the home and away fans egressing at the same area.
Again further analysis around crowd flow and available space is needed before confirming this consideration but, by reducing the crowd flow and number within the crowd by 50% (home fans egress in different direction), a larger space is available to accommodate the away fans. This method would enable the away fans to exit and board the coaches in a much shorter space of time.
Consideration for “Holdback”

The use of “holdback” is a police and stadia officials option when considering the restriction of egress away from the stadium where a section of fans, predominantly away, are held back in the stands post match by police and match day staff for a period of time.

This is often a contentious issue with fans attending certain fixtures and can often have a negative effect on fan behaviour, depending on how long and in what circumstances they are restricted.

When looking at the potential for holdback a major factor is to examine the suitability of the environment the fans are to be held in; other factors do include fan behaviour, threat and risk, potential for breaches of the peace etc.... This section concentrates on particular areas and themes based around the stadium build and its environment.

(Fig 22)

The first area to look at is in the single concourse area. As can be seen the concourse is narrow in width, approximately 4 metres in total, with a total length of approximately 65 metres. This total area space is calculated at a maximum of 260m². Again, this area is just the floor space area and does not account for a reduction in area due to bins (visual in Fig 22), match day staff and police etc....

The desired and safe capacity of the concourse requires the density as no more than 2 persons per m², utilizing the Green Guide. Using this figure and the relevant area space of this concourse, the number of people able to remain on the concourse is 520 persons, using the maximum space of 260m² at a density of 2 persons per m².
When considering the option of a hold back a quick calculation shows that for the 3,951 away fans in attendance for the SWFC v SUFC fixture, only 13% of the fans could be safely “accommodated in this area at any one time.

Further reductions of this percentage, as stated previously, would be necessary due to obstructions and a satisfactory clearance to allow free passageway to toilets and facilities, reducing further allowing for the clearance needed around the steps to and from the vomitries.

Although concourses are not designed to accommodate the full stand or capacity, a percentage of between 10% and 13% is on the low value, providing a heightened risk should there be a holdback in the stands.

To incorporate other areas, such as the enclosed area before egress, in to the holdback would also prove problematic. Figs 23 and 24 provide a visual aspect of the type of environment fans would need to stand in should a holdback be considered; including concourse and immediate environs prior to egress.

(Fig 23)
It is evident that the spaces and building lines are tight in design and numerous views are obstructed, creating a problematic space should any incident occur within the vicinity.

When considering a holdback option another critical area to be assessed and discussed is that of time and how long the holdback would be necessary for.

By using egress capacities and measurements from Fig 3 and the visual aspect from Fig 25 it is noted that the North Stand home egress has 3 x 2m exit doors, providing a total egress width of 6m.
Considering the previously used numbers and calculations, by having a total 6m width egress point, with an ability to egress at 82 people per metre per minute, provides this exit with the capacity for 492 people to pass through and egress per minute.

Using the 50% estimation of total capacity of the stand, 5,000 home fans would take 10.16 minutes to pass through the exit. This is based on a maximum flow with all the fans exiting in one “platoon” style formation.

Clearly this is not a true indication of how fans leave from the stadium; more common is that a number of fans leave early, a large proportion leave after full time and a number of fans leave sporadically after.

10.16 minutes is the absolute least time that the fans could leave through this point in a single mass. Time needs to be added for the factors mentioned, including time to leave the environs and various other areas. These additional considerations would increase the time needed to holdback the away fans even further.

As can be seen, the use of holdback in this scenario and scenarios similar to this is not advisable due to the factors described. Should a holdback be deemed necessary then considerations to use the area “outside” need to be considered. In its current layout, though, as seen in the review of the SWFC v SUFC fixture this would not be a safe option either. Analysis and a detailed review of the stages of crowd behaviour presented scenes of disorder and a tense, vulnerable situation.

The available solution for a successful, sterile and safe holdback option would be under the format detailed in Fig 18, where the egress area is solely used by away fans.

The holdback could be safely considered, utilising the area detailed with access to necessary facilities. Building lines would provide natural barriers, aiding police and staff deployments ensuring the area remained at safe capacity.
Conclusion and Recommendations

From the analysis and detail provided in this document it is apparent that a number of factors need to be addressed and considered for the continued safety of fixtures and events at Hillsborough Stadium.

A number of these points are linked and reliant on a change in behaviours and considerations, particularly in egress from the stadium.

Further analysis is advisable, particularly around total egress numbers and detailed accurate spatial measurements to ensure the figures presented accurately present the “real live” event.

Throughout the document a number of recommendations and considerations have been mentioned and noted;

These are detailed as follows:

- Recommended egress for home fans towards the East and not in its current format (That being towards Leppings Lane).
- A consideration to holdback is not advisable in its current format due to lack of available and safe space and time spent in the particular environment.
- Should the recommendation around home egress be accepted then the external design and available spaces, coach park etc... can be safely implemented.