Understanding Crowd Dynamics
Prof. Dr. G. Keith Still FIMA FICPEM SFIIRSM MEWI FIPM FHEA

12th June 2018

Prof. Dr. G. Keith Still FIMA FICPEM SFIIRSM MEWI FIPM FHEA

PhD interdisciplinary mathematics/psychology
28 years consulting experience (small, medium, large events)
UK Cabinet Office Emergency Planning College (EPC)
15 years of teaching the principles of crowd safety for major event (1999-2014)
International projects
UK, USA, Australia, Netherlands, Singapore, Hong Kong, Saudi Arabia
Expert witness (USA and Europe)
Washington (Senate House Committee testimony), New York State (personal injury), Overcrowding (licensing), Duisburg/Germany (mass fatalities), London Underground, Lava and Ignite (fatalities), JLS Birmingham, Hillsborough Inquiry (mass fatalities), Concert London (personal injury), Chicago Arena (personal injury), Las Vegas (personal injury), Memphis (overcrowding), Scotland Concert (personal injury)
City wide event planning experience
Makkah/Hajj (Saudi Arabia), Liverpool (LIMF and Matthews Street), Austin SXSW (USA), Lincoln Christmas Market, 2011 UK Royal Wedding, Brighton Pride, Manchester City Victory Parades, Leicester Caribbean Carnival, Notting Hill Carnival, Kendal Torchlight Carnival, Commonwealth Games (UK)

1989 Hillsborough (96 dead, over 700 injured)

2010 Love Parade (21 dead, over 540 injured)
A new ethos

“It is not enough to aim only at the minimum measure necessary for safety. That has been, at best, the approach in the past and too often not even that standard has been achieved. What is required is the vision and imagination to achieve a new ethos.”

Final Report on the Hillsborough Disaster

28 years later the jury finds for “unlawful killing” Those responsible now face criminal charges

2014/15 Shanghai (36 dead, 46 injured)

2017 Turin (1 dead, over 1,500 injured)

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Scale of the Incident</th>
<th>Failure Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>Hillsborough, UK</td>
<td>96 dead, 460 injured (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>1990</td>
<td>Miss Valley, Saudi Arabia</td>
<td>1429 pilgrims crushed (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>1991</td>
<td>Dhaka, Bangladesh</td>
<td>85 dead, many injured (Overcrowding)</td>
<td>Design (Capacity + Crowding)</td>
</tr>
<tr>
<td>1992</td>
<td>Jakarta, Indonesia</td>
<td>269 pilgrims crushed, 58 injured (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>1993</td>
<td>Gwajima, City, India</td>
<td>53 crushed, 108 injured (Overcrowding)</td>
<td>Design (Capacity + Crushed)</td>
</tr>
<tr>
<td>1994</td>
<td>Jakarta, Indonesia</td>
<td>22 pilgrims crushed, 43 injured (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>1995</td>
<td>Jakarta, Indonesia</td>
<td>133 pilgrims crushed, 434 injured (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>1996</td>
<td>Kaifeng, China</td>
<td>11 killed, 100 injured in stampede (Reaction)</td>
<td>Information (Weather + Running)</td>
</tr>
<tr>
<td>1997</td>
<td>Jilin, China</td>
<td>33 killed, 180 injured (Overcrowding)</td>
<td>Information (Weather + Running)</td>
</tr>
<tr>
<td>1998</td>
<td>Ellis Park, South Africa</td>
<td>43 dead, 389 injured (Over capacity - Overcrowding)</td>
<td>Design (Capacity + Crushed)</td>
</tr>
<tr>
<td>1999</td>
<td>Jakarta, Indonesia</td>
<td>8 dead, including 5 Children (Weather)</td>
<td>Information (Weather + Crushed)</td>
</tr>
<tr>
<td>2000</td>
<td>Yoshiba, Japan</td>
<td>10,000,000,000 crowd cross (Reaction)</td>
<td>Information (Crowd Crush)</td>
</tr>
<tr>
<td>2001</td>
<td>Warsaw, Poland</td>
<td>24,000,000,000 crowd (Reaction)</td>
<td>Information (Crowd Crush)</td>
</tr>
<tr>
<td>2002</td>
<td>Jakarta, Indonesia</td>
<td>249 pilgrims crushed, 292 injured (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>2003</td>
<td>Jakarta, Indonesia</td>
<td>37 dead, 78 injured in crowd crush (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>2004</td>
<td>Jakarta, Indonesia</td>
<td>361 dead, 303 injured crowd crush (Overcrowding)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>2005</td>
<td>Manila, Philippines</td>
<td>10 dead, 29 injured crowd crush (Reaction)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>2006</td>
<td>Yemen, Middle East</td>
<td>51 dead, 264 injured crowd crush (Reaction)</td>
<td>Information (Public Policy)</td>
</tr>
<tr>
<td>2007</td>
<td>Hassan, Pakistan, India</td>
<td>106 dead, 29 injured in stampede (Martial law)</td>
<td>Design (Crush)</td>
</tr>
<tr>
<td>2008</td>
<td>Pasuan, Java</td>
<td>23 dead, dozens injured in stampede (Reaction)</td>
<td>Information (Handouts)</td>
</tr>
<tr>
<td>2009</td>
<td>Addis Ababa, Ethiopia</td>
<td>22 dead, 135 injured Football (Reaction)</td>
<td>Design (Crush)</td>
</tr>
<tr>
<td>2010</td>
<td>Birmingham (JA), UK</td>
<td>60 injured, 4 bootstraped (JA) (Reaction)</td>
<td>Design (Capacity + Arrival Profile)</td>
</tr>
<tr>
<td>2011</td>
<td>Yokohama, Mito, Japan</td>
<td>26 dead, 96 injured (Overcrowding)</td>
<td>Design (Crush)</td>
</tr>
<tr>
<td>2012</td>
<td>Korean North Korea</td>
<td>63 dead, 94 injured (Overcrowding - narrow road)</td>
<td>Design (Overcrowding)</td>
</tr>
<tr>
<td>2013</td>
<td>Johannesburg, South Africa</td>
<td>74 injured (Overcrowding at entry gates)</td>
<td>Information (Traffic Flows)</td>
</tr>
<tr>
<td>2014</td>
<td>Dresden, Germany</td>
<td>21 dead, 51 injured (Overcrowding)</td>
<td>Design (Traffic Crush)</td>
</tr>
<tr>
<td>2015</td>
<td>Bihar, India</td>
<td>15 dead, dozens injured (Reaction)</td>
<td>Information (Over Reaction)</td>
</tr>
<tr>
<td>2016</td>
<td>Nador, Morocco</td>
<td>7 dead, 76 injured (Reaction)</td>
<td>Information (Main Stopped)</td>
</tr>
<tr>
<td>2017</td>
<td>Phnom Penh, Cambodia</td>
<td>200 dead, 303 injured (Overcrowding)</td>
<td>Design (Crowd Flow)</td>
</tr>
<tr>
<td>2018</td>
<td>Jakarta, Indonesia</td>
<td>102 dead, 44 injured (Overcrowding)</td>
<td>Design (Capacity)</td>
</tr>
<tr>
<td>2019</td>
<td>Istanbul, Turkey</td>
<td>38 dead, 64 injured (Overcrowding)</td>
<td>Design (Capacity)</td>
</tr>
<tr>
<td>2020</td>
<td>Braamfontein, Cape Town</td>
<td>7 dead, 30 injured (Overcrowding)</td>
<td>Design (Capacity)</td>
</tr>
<tr>
<td>2021</td>
<td>Jakarta, Indonesia</td>
<td>2 dead, 13 injured (Overcrowding)</td>
<td>Information (Police + Security)</td>
</tr>
<tr>
<td>2022</td>
<td>Cairo, Egypt</td>
<td>74 dead, many injured (Overcrowding + Running)</td>
<td>Information (Cymatic + Crowd)</td>
</tr>
<tr>
<td>2023</td>
<td>Cairo, Egypt</td>
<td>3 dead, dozens injured (Overcrowding) Design (Overcrowding)</td>
<td></td>
</tr>
<tr>
<td>2024</td>
<td>Argentina, Los Angeles</td>
<td>12 dead, dozens injured (Overcrowding) Design (Overcrowding)</td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>Almaty, Kazakhstan</td>
<td>36 dead, 31 injured (Overcrowding, railway platforms)</td>
<td>Design (Capacity + Crowd Management)</td>
</tr>
<tr>
<td>2026</td>
<td>Yekaterinburg, Russia</td>
<td>8 dead, 14 injured (Overcrowding)</td>
<td>Design (Capacity)</td>
</tr>
<tr>
<td>2027</td>
<td>Tashkent, Uzbekistan</td>
<td>90 dead, 100 injured (Overcrowding) Design (Capacity)</td>
<td></td>
</tr>
<tr>
<td>2028</td>
<td>Anyang, China</td>
<td>36 dead, 201 injured (Overcrowding) Design (Capacity + Crush)</td>
<td></td>
</tr>
<tr>
<td>2029</td>
<td>Lagos, Nigeria</td>
<td>14 Dead, 10 Injured (Design/Overcrowding) Design (Capacity)</td>
<td></td>
</tr>
<tr>
<td>2030</td>
<td>Muscat, Oman</td>
<td>29 dead, 48 injured (Overcrowding, narrow streets) Design (Capacity, Crowd Flow)</td>
<td></td>
</tr>
<tr>
<td>2031</td>
<td>Shanghai, China</td>
<td>36 dead, 64 injured crowd crush (Overcrowding) Design (Capacity+ Crowd Flow)</td>
<td></td>
</tr>
<tr>
<td>2032</td>
<td>Italy, Girona</td>
<td>26 dead, 50 injured (Overcrowding) Design (Capacity + Crowd Flow)</td>
<td></td>
</tr>
<tr>
<td>2033</td>
<td>Athens, Greece</td>
<td>30 dead, 66 injured (Overcrowding) Design (Capacity + Crowd Flow)</td>
<td></td>
</tr>
<tr>
<td>2034</td>
<td>Jakarta, Indonesia</td>
<td>24 dead, 59 injured (Overcrowding) Design (Capacity + Crowd Flow)</td>
<td></td>
</tr>
</tbody>
</table>

2015 - 2025: 10 years 10 incidents

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2019 - 2025: 10 years 10 incidents

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Examples of DIM-ICE risk model

**NORMAL CONDITIONS**

- **Design:** Structures, facilities, roads, etc.
- **Circulation:** Smooth flow of people or goods.
- **Egress:** Easy exit and escape routes.

**EMERGENCY CONDITIONS**

- **Design:** Buildings, roads, etc.
- **Circulation:** Obstructed flow of people or goods.
- **Egress:** Difficult exit and escape routes.

**Failure Elements**

- **Design:** Capacity, robustness, redundancy, etc.
- **Information:** Knowledge, communication, etc.
- **Management:** Organization, control, etc.

**Source:** MSc students
5 marching in step

6 people per square metre

Crowd density versus crowd flow rate

Shockwaves and crowds collapse?

The physics of a crowd collapse

How to identify the risks of crowd collapse
The accident pyramid and risk analysis

1  Death
10  Injuries
30  First Aid
600  Near Miss
Unknown  Unsafe Acts

What is a crowd/event “near miss”? 
Pressure building up - needs redesign

Imagine you have an egg ...

...and you try to push it back into the chicken.
Common open event questions (RAMP)

We don’t know how many people may come to the event...
...what is the best way to plan for a major event?

What direction will crowds approach and depart the area?
Route question (transportation hubs to and from event site)

What is your event capacity?
How much Area do you have? How will the area be used?

How quickly will these spaces fill?
What crowd Movements do we expect?
Over what period of time?

What type of crowd are we expecting?
People, demographics, families?

Routes - parade distribution/pressure

No immediate rail access

The Slide Rule

We sent a man to the moon by rubbing bits of plastic together

Leicester Caribbean Carnival

The premier multi-cultural event - Midlands (UK) 100,000
For 25 years high profile, city wide revenue
Low crime and disorder
Areas - Victoria Park – 90,000m$^2$

Model of the change of venue

Modelling New Year (London 2006 - 2016)

<table>
<thead>
<tr>
<th>Areas (see image)</th>
<th>Area (m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – Waterloo to Embankment Station</td>
<td>11,955</td>
</tr>
<tr>
<td>B – Embankment to Westminster Station</td>
<td>23,304</td>
</tr>
<tr>
<td>C – Parliament Square</td>
<td>2,092</td>
</tr>
<tr>
<td>D – Westminster Bridge</td>
<td>4,138</td>
</tr>
<tr>
<td>E – Belvedere Road</td>
<td>11,241</td>
</tr>
<tr>
<td>F – Royal Festival Hall</td>
<td>3,000</td>
</tr>
<tr>
<td>G – Waterloo Bridge</td>
<td>9,143</td>
</tr>
</tbody>
</table>

Google Earth - using simple powerpoint graphics. The visuals do all the work.

Site rejected - the event will not fit in the space!
Crowd fill predictor - movement

Flow Estimator

People (profile)

Composition, demographics, history

Previous behaviour (linked to performer/venue)

What do we know of this crowd?

Kim Kardashian - Millions of Milkshakes
Using models for decision support

Modelling work for the Sydney Olympics
Site analysis, crowd management plan
Control room systems

Crowd Condition Monitor

14 days
11m - 14m people
Jamarat Bridge 3,000,000 people per day

Risks - public and professional views

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One day course - Ipswich
Sample from a risk assessment

<table>
<thead>
<tr>
<th>Hazards</th>
<th>Persons at risk</th>
<th>Risk factor</th>
<th>Measures to control the risk</th>
<th>Action</th>
<th>Revised risk factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trips, slips or falls</td>
<td>All at event especially the aged or those carrying objects</td>
<td>4 x 2 = 8</td>
<td>Pre-event check to remove loose material and level uneven ground. All cables buried or at high level. Information about uneven ground and correct footwear</td>
<td>Bill</td>
<td>2 x 2 = 4</td>
</tr>
</tbody>
</table>

We need to identify the following:

**Location**
Risk may be focussed at a specific location

**Duration**
Risk may exist for a short time (entry/exit systems)

**Severity**
Risk may be high or low at different times

Event ingress risk mapping

Mid-event risk mapping
Event egress risk mapping
Inter-professional communications

<table>
<thead>
<tr>
<th>TO</th>
<th>EDC</th>
<th>Police</th>
<th>First Aid</th>
<th>Security</th>
<th>Ushers</th>
<th>City Health</th>
<th>Caterers/Licensees</th>
<th>Promoter</th>
<th>Crowd</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDC</td>
<td>Direct contact</td>
<td>Command post</td>
<td>Direct contact with EDC</td>
<td>Direct contact with EDC</td>
<td>Direct contact with EDC</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>All signs &amp; directions clear and, where appropriate, staffed areas TID</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Police</td>
<td>Command post</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with police</td>
<td>Direct contact</td>
</tr>
<tr>
<td>First Aid</td>
<td>Command post</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with first aid team</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Security</td>
<td>Command post</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with security</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Ushers</td>
<td>Ushers go to</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with ushers</td>
<td>Direct contact</td>
</tr>
<tr>
<td>City Health</td>
<td>Direct contact</td>
<td>Through EDC</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with city health</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Caterers/Licensees</td>
<td>Command post</td>
<td>Through EDC</td>
<td>Direct contact</td>
<td>Through EDC</td>
<td>Through EDC</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with catering team</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Promoter</td>
<td>Association manager</td>
<td>Through EDC</td>
<td>Direct contact</td>
<td>Through EDC</td>
<td>Through EDC</td>
<td>Direct contact</td>
<td>Direct contact</td>
<td>Direct contact with promoter</td>
<td>Direct contact</td>
</tr>
<tr>
<td>Crowd</td>
<td>Through tee &amp; into main concourse</td>
<td>Through concourse, concourse</td>
<td>Through concourse, concourse</td>
<td>Through concourse, concourse</td>
<td>Through concourse, concourse</td>
<td>Through EDC</td>
<td>Through EDC</td>
<td>Direct contact</td>
<td>Direct contact</td>
</tr>
</tbody>
</table>

Application for congestion

<table>
<thead>
<tr>
<th>Crowd Density/Movement - Risk Profile By Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Areas</td>
</tr>
<tr>
<td>Charging</td>
</tr>
<tr>
<td>VIP</td>
</tr>
<tr>
<td>taxi</td>
</tr>
<tr>
<td>Paddington Gates</td>
</tr>
<tr>
<td>Moorgates Gates</td>
</tr>
<tr>
<td>Station</td>
</tr>
<tr>
<td>Trafalgar</td>
</tr>
</tbody>
</table>

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Operational Research and Crowd Science

Forecasting Arrival and Departure rates

Queueing Theory (linked to behaviour)

Area - time - density and movement

Incident - location - risk - response

Figure 3: The application of a Decision Support System to enhance the safety of a mobile event and public assembly.
Decision trees “What if” scenario planning

Activity Cycle Diagram

Capt. Marcel Altenburg MA PGDip

Captain and Unit Commander in the German Federal Armed Forces
12 years leading and training ground combat troops

Leading role in control rooms and situation rooms
Military and civilian

MA in Human Science
Hamburg University and Helmut-Schmidt-University, Germany (2008-2012)

MSc Student in Crowd Safety and Risk Analysis
Manchester Metropolitan University (since 2015)

Enterprise Delivery Fellow at MMU
16th Jan 2017 (4 days before the inauguration)
2 years working with me on international projects
Using Google Earth to estimate the distance

From Lincoln to Obama, How Crowds at the Capitol Have Been Counted

Using Google Earth to approximate the field of view

This maps to a ground area calculation

Ignoring safety, what’s the maximum number of people that can fit in Times Square?

31st Dec 2016
Approximate field of image view (1,410 m²)

1410 m² x 5 people per square metre = 7,050 people


The average height is 5 ft 7 in.
The average weight is 137 lbs


The average height is 5 ft 9 in
The average weight is 166 lbs

+20% body mass, we can assume a 6 people per square metre packing density for smaller body sizes (even in Winter)

4 March 1861

Head Count (Approximation)

7,350 people

5,000 people

2,000 people

50 people

300 people

Boasting of 3,000,000 people

“Can you guys do this LIVE?”

“I think I’ve been treated very rough. I will say the Times is about the roughest of all.”
Donald Trump to the New York Times
**Routes for the inauguration 2017**

What area can the crowd occupy?

**Area for the inauguration 2017**

**New York Marathon 42.195km**

42 km x 2 sides = 84,000m

x 2 (people per metre) = 168,000 people

x 18 deep (both sides) = 3,024,000 people
Obama (2009) high resolution images

Estimated 1.8 million people would cover 720,000 m²
Obama crowd (2009) occupied 175,000 m²
400,000 to 500,000 people

From the White House website we had the area allocations
We can measure these areas using Google Earth Pro

Crowd Dynamics
Routes, Areas, Movement (transport and parking capacity)
Then monitor the crowd build up on the day
How the space is filling over time

The Bowl
70,000 people
Between 200,000 and 267,400 people
If 100% occupied space
250,000 tickets

Penn Avenue = 7,300m²
Union Square = 20,000m²
Maryland Ave. = 5,300m²
Mall Standing = 33,200m²
Total area = 65,800m²

At 2pm² = 131,600
At 3pm² = 197,400

Bowl = 39,346 m²
-10% for spaces
35,000 m² of seating
All seated 2 people per square metres
70,000 people (approx)
Only part of the mall area was covered
We can see the white flooring (used in 2013)
The media tent is the end of the viewing space
No one can see from behind the tent

The Mall area was 200,000 m²

For safety, the sections are divided
Barriers and the media tent
It could hold 500,000 people (@ 2.5 pm²)
If fully occupied (includes the Mall Standing area)

Movement (metro and parking - live)

D.C. METRO RIDERSHIP
As of 11 a.m., ET on previous inauguration days and Jan. 21

Compare to 2009

<table>
<thead>
<tr>
<th>Date</th>
<th>Ridership</th>
<th>2009 Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 20, 2005</td>
<td>197,000</td>
<td></td>
</tr>
<tr>
<td>Jan. 20, 2009</td>
<td>513,000</td>
<td>100%</td>
</tr>
<tr>
<td>Jan. 20, 2013</td>
<td>317,000</td>
<td></td>
</tr>
</tbody>
</table>

Currently the best access to #inaug2017 is from 7th and Indiana Street and 14th and E Street.
Stay flexible, patient and safe.
Time lapse of the 2017 inauguration

From the 2009 satellite images we can measure the high density areas. The front 1/3rd (beyond the reflecting pool) was full in both events. The back 2/3rd’s were empty for 2017.

The New York Times published the article, using the above graphics. We had confirmation in the visuals, the area analysis, the crowd build up over time and the metro data. All point to 1/3rd the Obama crowd.

Measuring the satellite images

The high density areas were 1/3rd of 2009

At 11am 193,000 trips (2017)
Comparing the crowds at Donald Trump's and Barack Obama's inaugurations

The viral tweet

“I made a speech, I looked out..”

George W. Bush made international headlines trying to pull on a poncho during the speech

Global news coverages - rained throughout

It was a mostly empty field
Not packed to the Washington Memorial,
3rd to 9th only partially full
6 blocks not 20
It was raining throughout
Great job guys, could you count the Women’s March today?

How big would this crowd be?

Will this become a story?

New York Times (21st Jan 2017)

Metro Ridership as of 11am: 275k. For comparison, that’s more than 8x a normal Sat & even busier than most weekdays.

#wmata #womensmarch

TRUMP INAUGURATION: 393
WOMEN’S MARCH: 1,200
OBAMA 2009 INAUGURATION: 3,000

SOURCE: D.C. OFFICIALS

Inauguration
61,000m²

Women's March
180,000m²

Metro @wmata - Jan 21

Washington metro ridership

Sat’s march in Washington overwhelmed the city’s Metro subway system, with enormous crowds reported and some stations temporarily forced to turn away riders.

D. C. METRO RIDERSHIP
As of 11 a.m. ET on previous inauguration days and Jan. 21

<table>
<thead>
<tr>
<th>Date</th>
<th>Ridership</th>
<th>% Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. 20, 2005</td>
<td>197,000</td>
<td>100%</td>
</tr>
<tr>
<td>George W. Bush’s 2nd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan. 20, 2009</td>
<td>317,000</td>
<td>37%</td>
</tr>
<tr>
<td>Barack Obama’s 1st</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan. 20, 2013</td>
<td>513,000</td>
<td>54%</td>
</tr>
<tr>
<td>Barack Obama’s 2nd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan. 20, 2017</td>
<td>193,000</td>
<td></td>
</tr>
<tr>
<td>Donald J. Trump’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan. 21, 2017</td>
<td>276,000</td>
<td></td>
</tr>
<tr>
<td>Women’s March on</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Official Twitter feed of the Washington Metropolitan Area Transit Authority (WMATA)

C. Chan 22/1/2017
New York Times - graphics department

- 2009 Obama
- Washington Monument
- Capitol
- 2017 Trump
- Women's March
- 1/4 Mile

Saturday 21st Jan 2017

Kellyanne Conway - Counsellor to the President

Crowd Scientists Say Women's March in Washington Had 3 Times as Many People as Trump's Inauguration

The women's march in Washington was roughly three times the size of the audience at President Trump's inauguration, crowd counting experts said Saturday.

Marcel Allenberg and Keith Still, crowd scientists at Manchester Metropolitan University in Britain, analyzed...
Trolls - these are NOT at the same time

We can see Obama and Trump on the screens!

Independent validation (hi-resolution images)

440,000 +/- 10% during the march

Our count was in real-time during assembly 470,000 +/- 10%

Crowd counting estimates vs hard count
“A new ethos”

Balancing Safety and Security

Any questions?