CROWD SCIENCE: SAFETY AND RISK ANALYSIS

By **Prof. Dr. G. Keith Still**

ABSTRACT

"Before beginning, plan carefully." Marcus Tullius Cicero (106 BC - 43 BC)

"The single biggest problem in communication is the illusion that it has taken place." George Bernard Shaw (1856 - 1950)

The conventional approach to risk assessment, for crowds in places of public assembly, is to evaluate the likelihood and consequences of an accident or incident and then to multiply these two numbers together. The risk assessment documentation is presented as a table that includes the total, a brief description of the risk and an equally brief risk mitigation note. The table based approach to risk analysis represents the risk as a static value, one number, one description, and fails to describe the basic characteristic of places of public assembly; crowds are by their very nature, dynamic. We need a new approach to understanding crowd risks and a method of defining the dynamics risks for major events.

The conventional approach is flawed for several reasons.

- Numerical bias in estimation risks
- The process is often marginalised (cut and paste from previous documents)
- Information is lost in the process.

NUMERICAL BIAS

The typical risk analysis classifies the potential risks into two defined values. The first is called the likelihood of the risk occurring, the second is the consequence of the risk occurring. These are typically shown as a multiplication table similar to the one below.

Risk	Consequence				
Likelihood	1 - Minor	2 - Medium	3 - Major	4 - Critical	5 - Extreme
5 - Certain	5	10	15	20	25
4 - Likely	4	8	12	16	20
3 - Possible	3	6	9	12	15
2 - Unlikely	2	4	6	8	10
1 - Rare	1	2	3	4	5

When you multiply these two numbers you define a single value which is then assigned to a specific risk. A score of less than 5 will be a "low risk" a score between 5 and 10 will be a "medium risk" and a score of 10 or above will be a "high risk." From a numerical perspective, there are 10 boxes defined as "high risk" definition (10/25 = 40%), 8 boxes that are less than 5, "low risk", (8/25 = 32%) and the remaining 7 boxes are medium risk (7/25 = 28%). 68% of the table is therefore biased towards "medium" and "high risk."

The process of multiplying two numbers biases the table towards the higher risks, hence the final value is typically higher than expected. This bias fundamentally over-estimates the "value" of the risk. There are numerical methods of removing this numerical bias, but these are rarely used in the events industry. Also, the assignment of a single value can be both inappropriate and misleading for any risks that are dynamic in nature.

MARGINALISATION

The process of completing a risk assessment takes time. The risk assessor has to visualise the risk, define the likelihood and consequences of the risks, describe the risk, define the mitigation process and then document the risk assessment. There are software database systems, form filling tables, that expedite this documentation process, but this is just the start. In itself, the risk assessment/documentation does nothing, the process of risk management is not solved by filling in the forms.

Equally it takes a lot of time to read the risk assessment, to

process the information, to re-visualise the risks and define an action plan for crowd management. Over the last 25 years, and specifically, as an expert witness in prosecution cases, the risk assessment document is one of the first documents that are scrutinised. Failure to adequately define the risks to the individuals in a crowd are one of the simplest things to identify from the risk assessment and risk management plan.

MISSING INFORMATION

The third, and most important point, of the crowd risk analysis process is that is fails the basic principles of Information Theory (Shannon 1949). It is impossible to reconstruct the conditions that give rise to many crowd related risks, risk that are dynamic in nature, from the risk assessment documentation. The process described above produces a single number, a static value. Crowds are dynamic in nature, and crowd risks can change over time.

INFORMATION THEORY FAILURE

We stated that the standard form of the risk assessment fails the principles of information theory, in that the information is recorded and, at some point in the future, someone else need to pick up this document and decode the record back into useful information. For example, the statement in the above risk assessment "anticipated crowd capacity and ensure facilities are adequate" is missing at least three elements of information.

Location – where in the system does this apply? What are the anticipated crowd capacities and arrival rates? Which facilities are there likely to be problems? How would we recognise those problems? What is the definition of "adequate"?

Duration – the entry system may have specific time that the risks are higher (for a football match this may be the last 15 minutes before kick off, for a concert this may be several hours prior to gates open). Elements around the site may also have time related risks such as transport terminals. There is no provision in the risk assessment template to outline duration?

Severity – the risks may fluctuate, may be dependant on external factors. For example, crowd crushing may be a result of weather (seeking shelter), of transport delays, arrival of a celebrity, there are many factors that can influence the number of people in specific sections of an event and the risks need to relate to this dynamic. Severity can be a function of the difference of the arrival rate and the throughput rate. Some queueing may be necessary.

THE IMPORTANCE OF A RISK ASSESSMENT

When investigating major incidents, the risk assessment one of the first

documents to be reviewed. One of the key questions is:

"Did the event organiser, approval/licensing/permitting officer and operations teams understand the risks during the event?"

Clearly, if the process has been poorly documented, individuals and organisations are potentially open to claims of negligence. To illustrate how the process can (and does) go wrong let us work through an example.

CROWD RISK ARE DYNAMIC

We need to understand the dynamics of risk for crowds. An event will typically have three primary phases of crowd movement, ingress (where the crowd approach the venue and pass through the entry system), circulation (where the crowds move around the various points of interest within the event) and egress (where the crowds leave the event). We can have an emergency during ingress, during circulation (mid-event) and during egress. So there are three distinct periods, each of which should require a normal and emergency/contingency plan. This is often overlooked and an evacuation plan will typically only refer to the mid-event emergency. However, if the crowd are in the process of entering a system and there is a need to evacuate at that time, it is a very different set of challenges than a mid-event evacuation.

Two things should now be obvious. The first is that the form above does not lend itself to the necessary description of the dynamics of crowd risks. The second is that a single value (medium, high, 15, etc.) does not represent risks that have a specific duration that may be high for a short time, then zero for the duration of the event. If we consider the risk of crowd crushing during ingress/entry systems, this page is a recent image from a USA stadium.

A trip, slip or fall in this area could have fatal consequences, but this is a very short duration, outside the stadium, not noticed by the staff (inside the stadium) who are all busy.

VISUALISING THE DYNAMICS OF RISK

The challenge was to devise a method that would both be simple to implement, and provide useful information for the person who both evaluates and manages crowd risks.

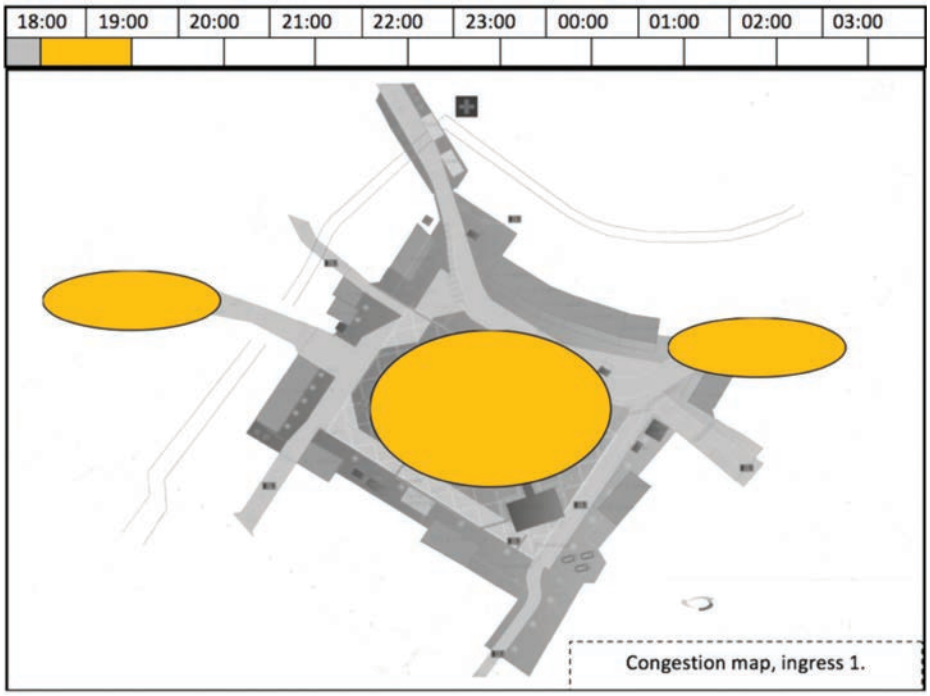
We need to identify the following:

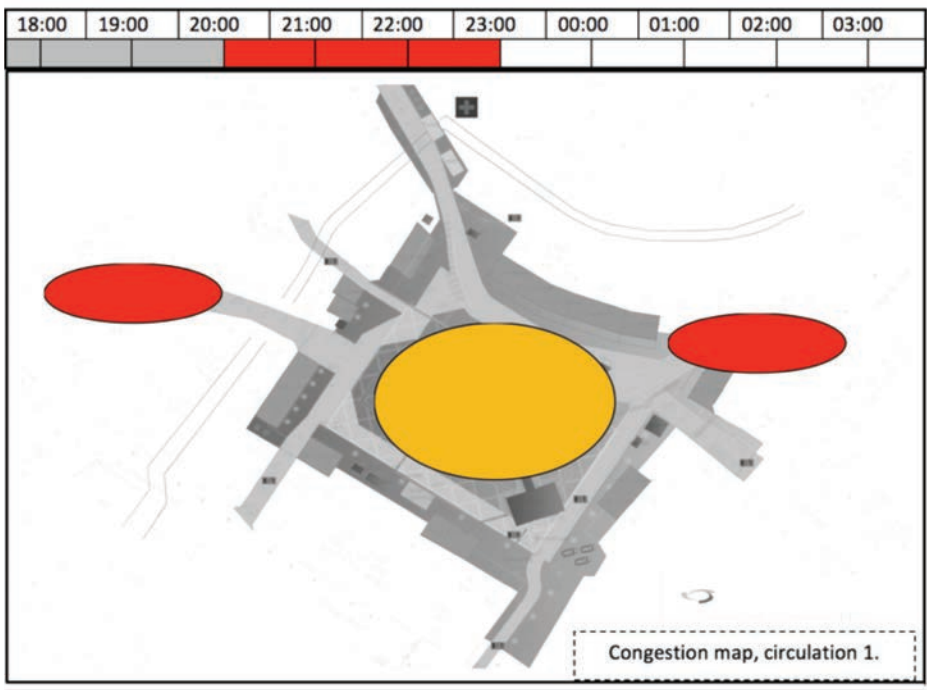
Location - Risk may be focussed on a specific location.

Duration - Risk may exist for a specific time

Severity - Risk may have different levels of severity at different times

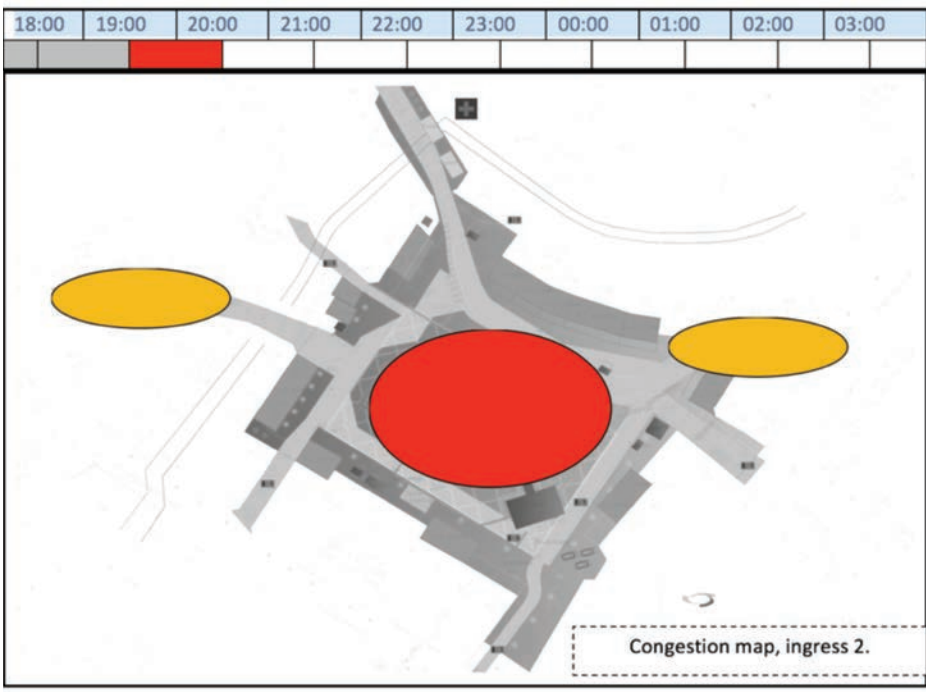
We can do so by mapping the risk. Rather than try to explain the process, let us show you a dynamic risk map. There is timeline across the top, and red amber

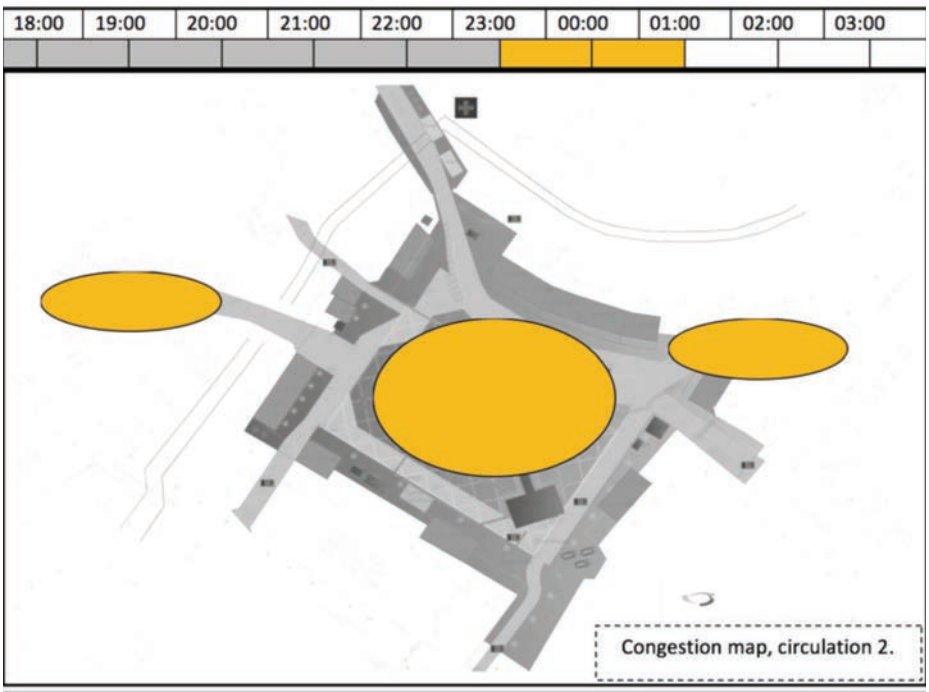




green represents the congestion in these locations, at those times.

We can see in a few images, the evolution of the crowd dynamic (and congestion over time). They say a picture is worth a thousand words, try and describe these images in words and you'll see how much information is transmitted in a few simple diagrams.





CONCLUSION

The conventional approach to risk assessment using a static number and notation often fails to describe the potential problems, specifically for crowd movements in places of public assembly. A competent person can calculate the volume and capacity of the system, but the information can be lost in translation.

A picture paints a thousand words, a thousand words in a risk analysis or event plan can be difficult to visualise. Try drawing your event, illustrating the crowd flow, the directions of approach. Try colouring areas of high-risk red, medium risk orange and low risk green. Do this for a series of diagrams, each illustrating a part of the site at a different time. You have now mapped the dynamics of risk in such a way that a layperson can pick up the document and understand the location, duration and severity of a dynamic risk.

The test of your risk assessment should always be related to the information it presents to the reader. If a layperson, someone unrelated to your event, cannot understand the document, then you need to ask yourself, is this fit for its intended purpose, would this stand up to scrutiny in a court of law?

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His courses have run at the UK Cabinet Office Emergency Planning College, Universities and client sites around the world for over 25 years. Over the last two decades, Keith has consulted on some of the world's largest, and most challenging crowd safety projects in the world. He is a Fellow of the Institute of Mathematics and its applications. (FIMA) a visiting Professor of Crowd Science (Bucks New University), a regular visiting speaker at Easingwold (the UK Cabinet Office Emergency Planning College 1999 - 2014), a member of Mensa for over 30 years, a Fellow of the Institute of Civil Protection and Emergency Management (FICPEM), a Specialist Fellow of the International Institute of Risk and Safety Management (SFIIRSM), the Professor of Crowd Science - Manchester Metropolitan University (MMU), a Member of the Expert Witness Institute (MEWI) and a Fellow of the Institute of Place Management (FIPM).