Technical Paper

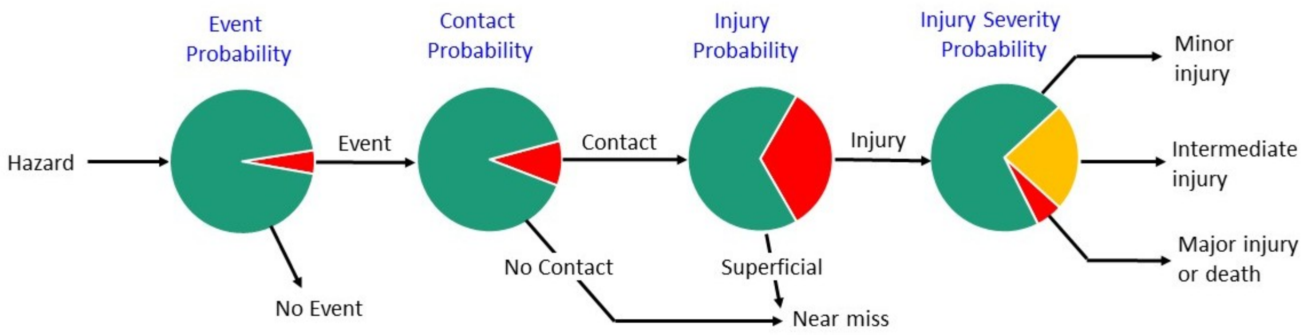
WhitePaper No. 33

How probabilities combine to determine the outcome of an event

Author: Phil Chambers BSc, CMIOSH

Safety professionals should be aware of the Bird/Heinrich Triangle, which shows that if you have enough incidents, then eventually you will have a serious injury. Some people have proposed a model of slices of Swiss cheese where the holes line up, and an excellent article by Neil Budworth in the March 2013 issue of SHP talked about near miss data. However, nobody, to my knowledge has properly explained why the Bird Triangle should be so. Some people use a "Swiss Cheese" model in training courses but always fail to explain why the holes in the cheese line up. The model I describe below explains this and, more importantly, points to how improvements can be made.

The model I show below is based on probabilities, ranging from 0 (will never happen) to 100% (will happen every time) and shows what determines the different outcomes.
You could use 0 to 1 which makes it easier to multiply the different probabilities



1. If we have a hazard, then there is some probability that is will lead to an event. I have shown this as either red or green.
2. If there is an event (the red part), then there is the probability that someone or something will be in the way and contact occurs.
3. If contact occurs, then there is a probability of it being a glancing blow or one which causes injury.
4. If an injury occurs, then there are probabilities of the severity of the injury.

With the weightings of this diagram, we have something like a probability of 10% x 20% x 30% x 10% (ie 6%) of death.

It is because of these probabilities that we can generate the Bird triangle, given sufficient data.

We can affect some of these probabilities, and PPE affects the injury severity; eg seat belts reduce the injury severity in a car accident.

However. others such as the injury probability, are normally out of our control. And as a general principle, the measures to be taken should be as far left (what I call upstream) as possible. That is why PPE is rightly regarded as the least preferable control measure as it only affects the far right probability.

There is a probability of poorly stacked reels falling. This is most likely to occur when vehicles are near reels such as when they are being moved. A photograph (not in this article) taken the next day showed that it had all changed (with no improvement). So therefore there was a high frequency of movement which would mean that the probability of a reel falling was high.

There is then the probability of contact, ie with somebody next to a falling reel. The photograph on the right shows a walkway to another area and this was the primary route into this area. Therefore, the probability of contact was high.

Then if contact occurs, there is the probability of injury. With these reels, which can weigh several hundred kilograms, there is a high probability that any contact would be more than a glancing blow.

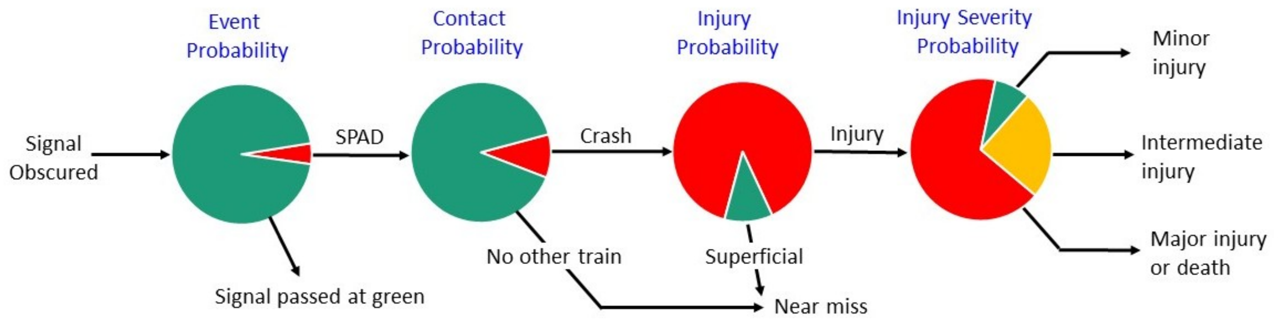
Finally, there is the probability of the extent of injury. With these heavy reels, the probabilities of major injury and death are both high.

By examining the probabilities, we can see several remedial steps:

1. Reduce the probability of toppling by better stacking practices, eg large diameters at the bottom.
2. Reduce the probability of contact by storing the reels away from the walkway, moving the walkway elsewhere, or by building a steel cage that prevents a falling reel from reaching the walkway.

The injury and injury extent probabilities would remain unchanged, but because we have changed the upstream probabilities, this is no longer critical.

For another real example of which many people are aware, I'll take the Paddington rail crash. This was caused by a train outbound from Paddington going through a red signal (SN 109) and colliding with the inbound train.



If the signal is obscured or badly sited, as was the case here, then there is a probability that a driver will miss the red signal. Technically, this is called a Signal Passed At Danger (SPAD). There had been 8 SPADs at SN 109 in eight years. I don't know how many trains had stopped when it was red over that interval, but dividing 8 by that number would show the probability of it happening.

Once a SPAD occurs, there is the probability of a train coming the other way. This is a high probability as the signal would have been set at red because of just this, and it is only the safety margin which makes it not 100%. As the crash happened on the 9th SPAD, the probability is of the order of 1/9, ie 11%. I apologise for the crude statistics in both these calculations, but you get the idea.

With a train crash, the probability of injury is very high, and the probability of those injuries being fatal is again very high.

This is a simplification of the Paddington crash, and there were other contributory factors such as driver training. However, it does illustrate how this model works.

A common failing in so many accidents is to fail to take action until injury or death occurs, but consideration of this model shows the wisdom of reacting to upstream indicators.

What this model should lead us to do is:

1. To reduce hazards so far as is reasonably practical by using techniques such as risk assessment or employee hazard reporting.
2. Identify where a major improvement in overall probability can be made.
3. To regard incidents or near misses as being the same as an accident.
4. To regard minor injuries as seriously as major injuries in circumstances where luck determines the outcome.
5. To apply control measures to the upstream end.

All action management systems should have the ability to record whether something was a hazard, a near miss or an accident and to provide counts of these for management information. Just recording accidents is not good enough. Good safety control is where you have a high count of hazard corrections, a lower count of near misses and a very low count of accidents.

Whilst you may not make formal calculations of probability, I suggest that considering them will derive major benefits in your risk assessment, near miss and accident management programmes.

Strategic Safety Systems Ltd., 8 The Highgrove, Bishops Cleeve, Cheltenham, GL52 8JA, UK
Phone: 01242 679713 Mobile 077680 11667
E-Mail: info@StrategicSafety.co.uk Web site: www.StrategicSafety.co.uk