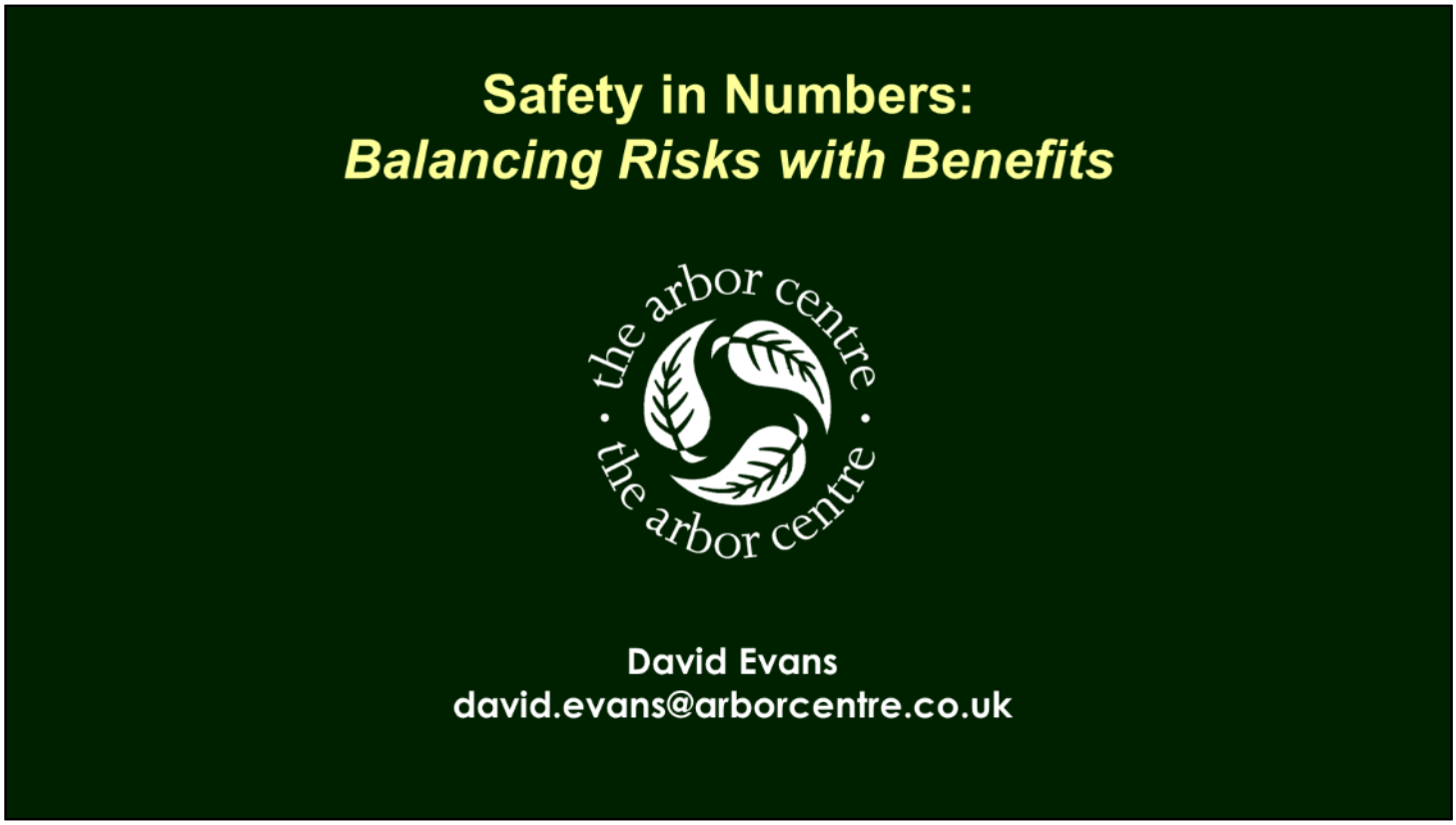
This is an enhanced transcript of 'Safety in Numbers', which I presented at the ISA 2015 conference in Florida, USA. I have added more detail where I think it might be useful to the PowerPoint slides and notes format. Some hyperlinks are included in the notes, and in the event of a problem with these I've suggested a search phrase that should take you to the site and page.

Cheers

David



Hi, and thank you for coming along to hear me speak.

I'm going to start off with some words about numbers.

The Scottish Philosopher, and failed milliner, Tomas Reid said,

"There is no greater impediment to the advancement of knowledge than the ambiguity of words."

So, let's get straight into some numbers.

T Minus 5

4

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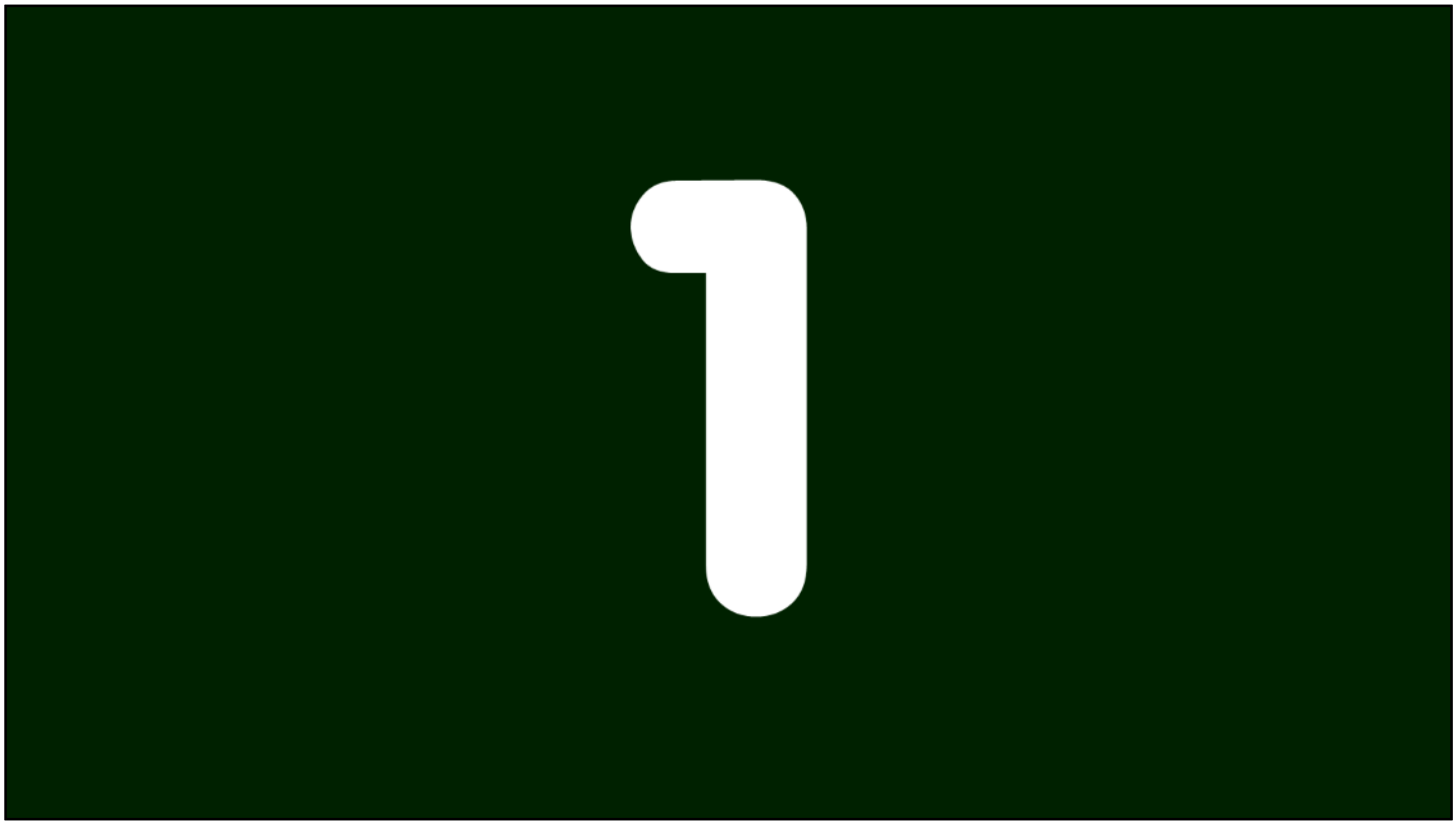

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Solid rocket booster ignition.

We have lift off!

This is the Space Shuttle Discovery launching on Mission STS-48.

In numbers, around 60 miles down the road at Cape Canaveral.

In words, this could be a short, medium, or long distance.

Here's the date of launch in numbers, as it would be displayed in the USA.

In words, we might say – sometime ago, back in the day, or even donkey's years.

Part of the Discovery's payload was the Upper Atmosphere Research Satellite (UARS).

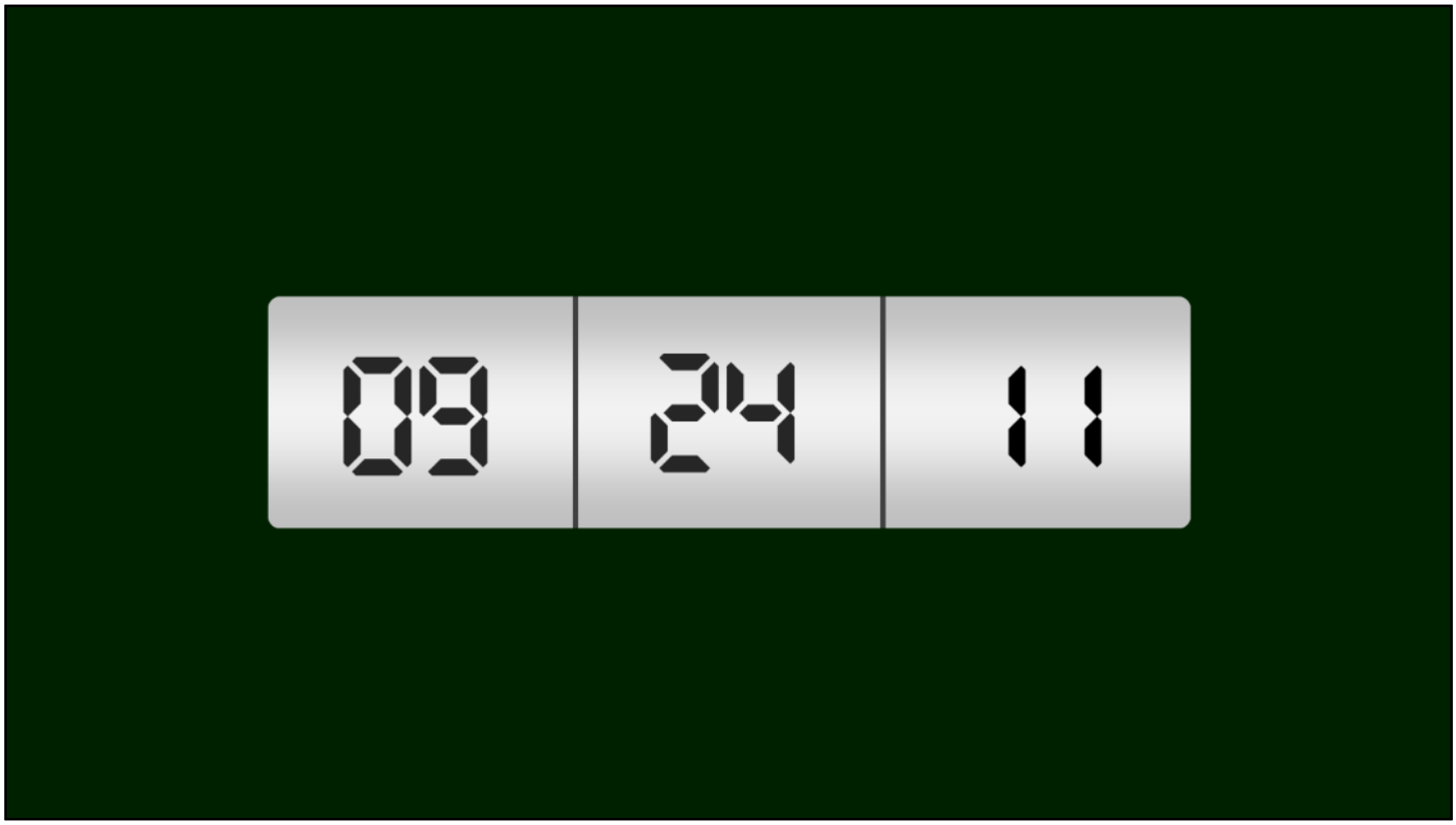
The UARS happily orbited the earth doing its business, year after year.

In numbers, it did this for 14 years until it was eventually retired in 2005.

In words, this could be a short, medium, or long time.

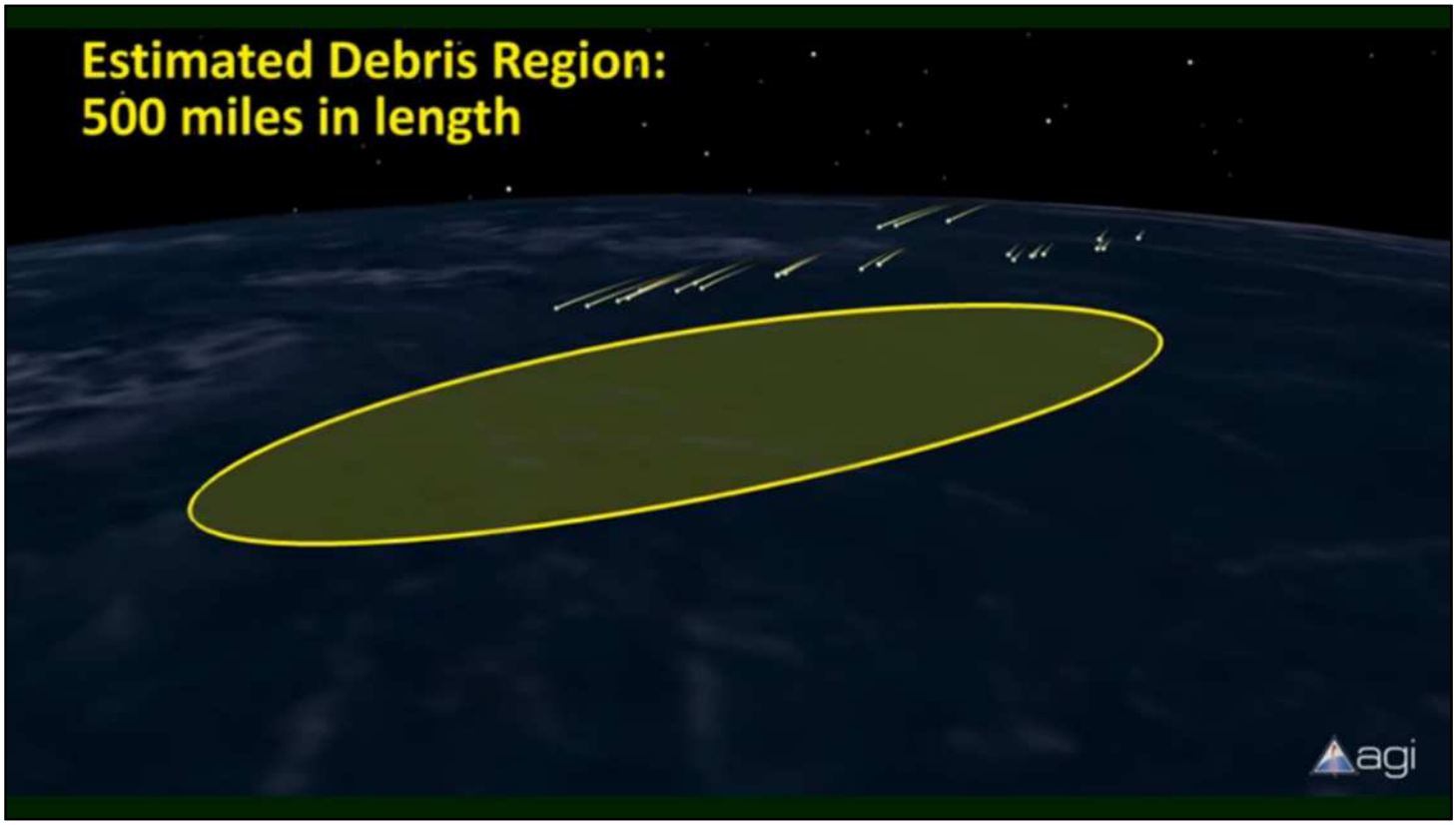
In numbers, after 6 years of well earned retirement the UARS decided to come home, and fell back to earth.

In words, this could be a short, medium, or long time.



Here's the date it was due to arrive back home in numbers.

In words, we might say - sometime ago, back in the day, or even donkey's years.



The homecoming of the UARS was not planned by NASA and re-entry was uncontrolled.

In numbers, 26 pieces of debris were expected to survive re-entry and hit the earth.

The largest piece had an estimated mass of 158.30 kg (348.99 lb).

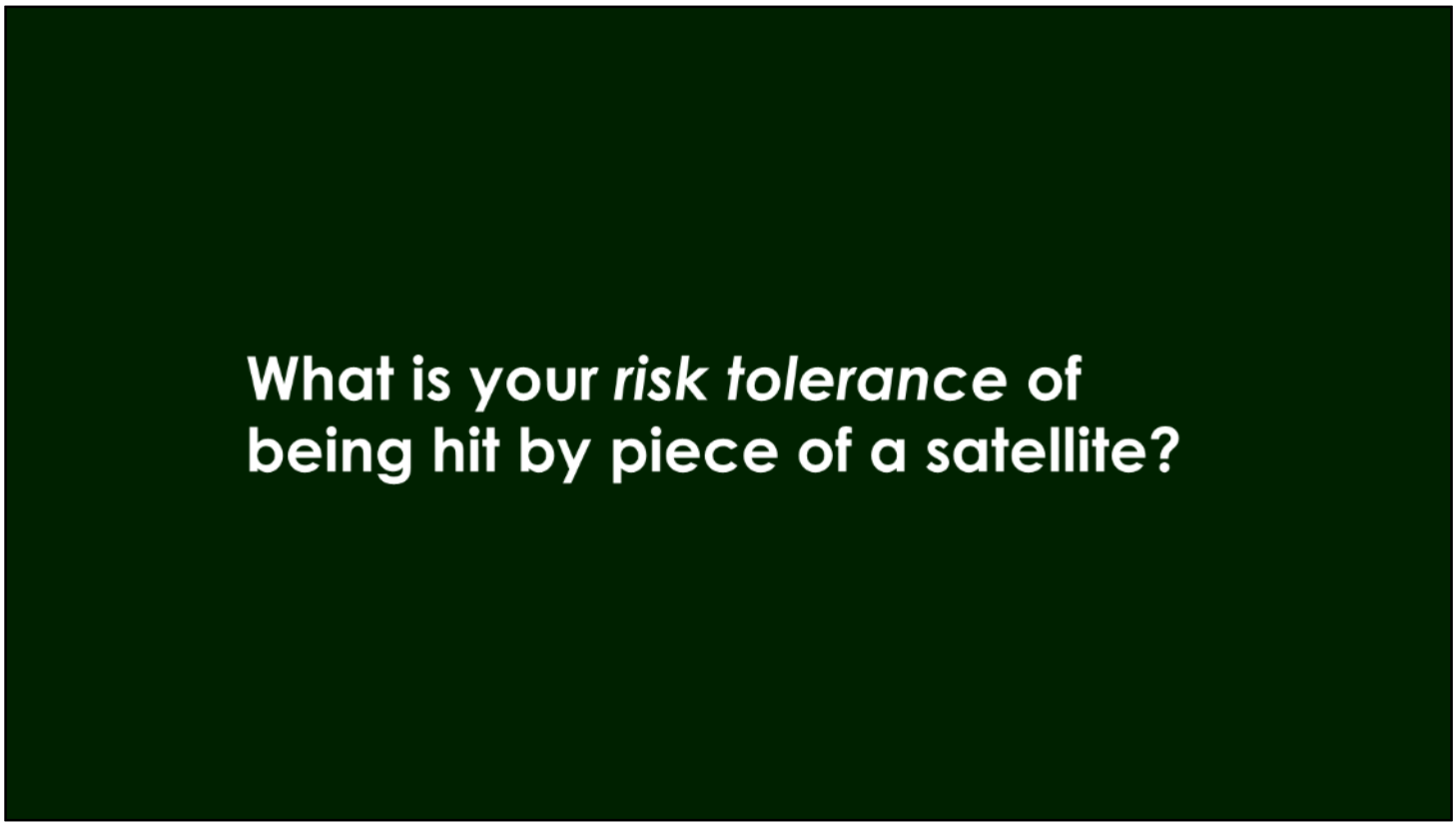
In words, we might say many or not many, large or small pieces of debris, were going to survive re-entry and be spread over a large or small area.

To help visualise the numbers here.

A mass of 158.30 kg (348.99 lb) is similar to being blocked by a free-falling King Dunlap.

But with less give.

Let's take a straw poll and find out what your 'risk tolerance' is to being tackled by a free-falling King Dunlap using words.

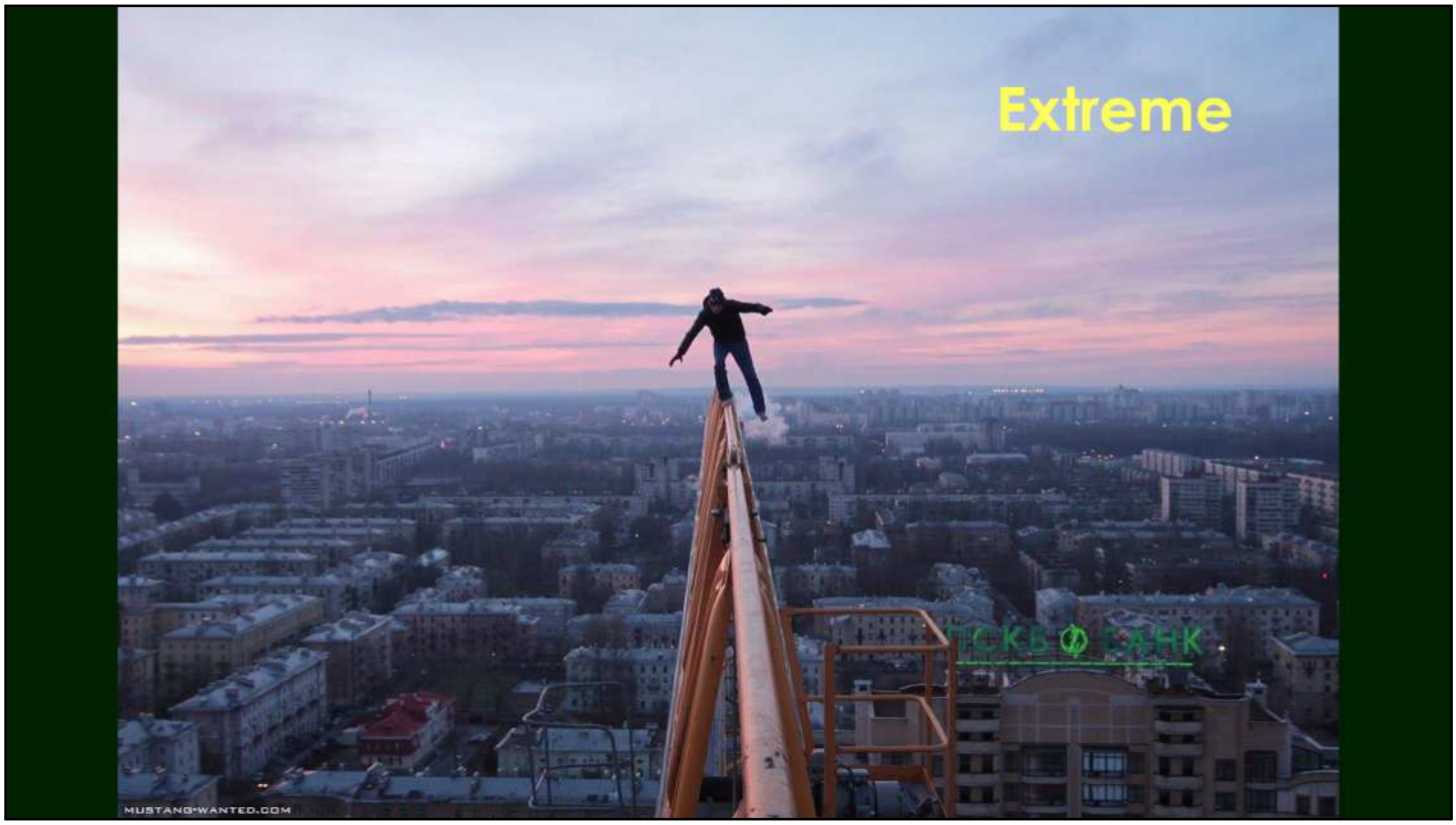


What is risk tolerance?

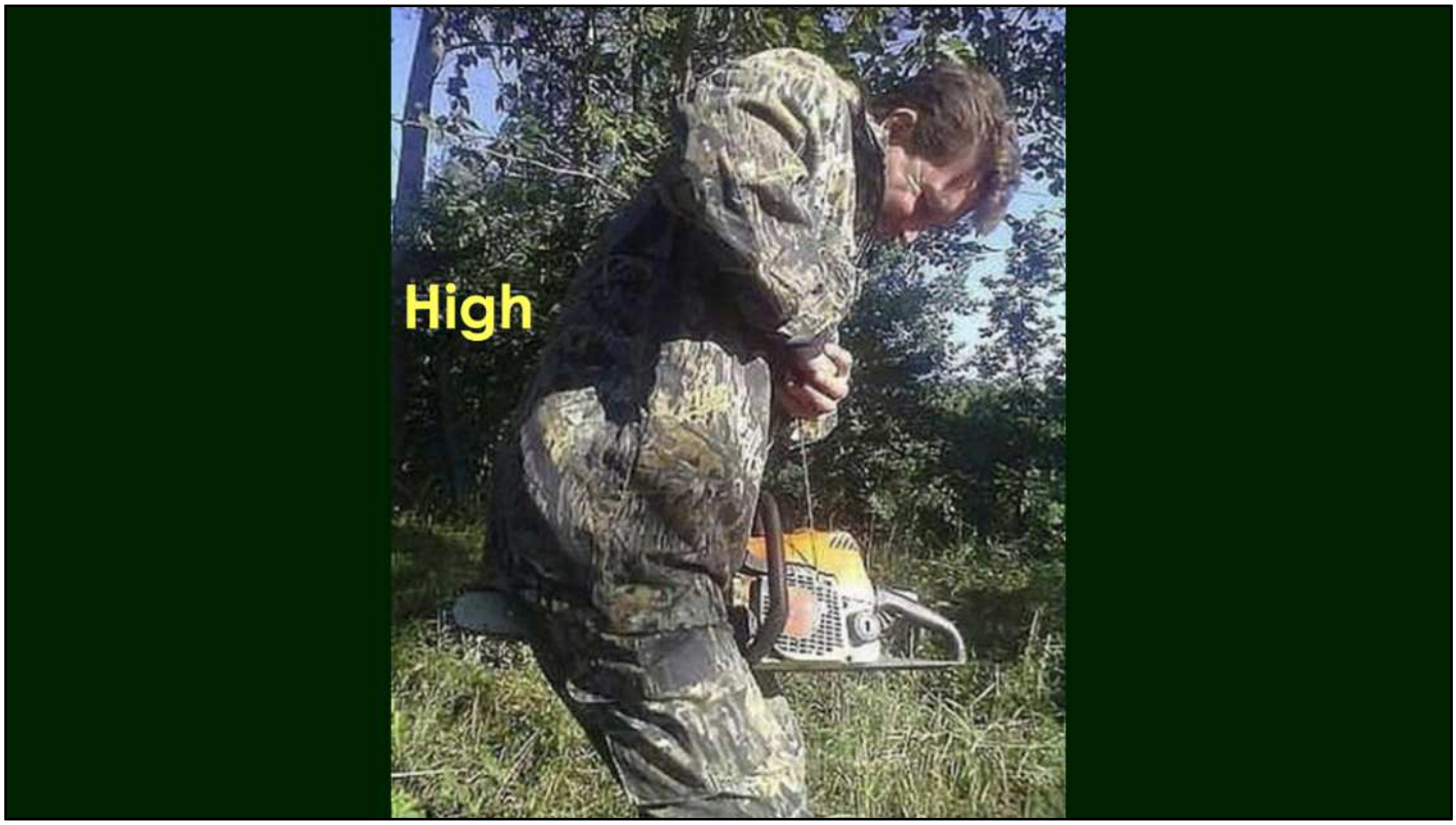
Risk tolerance simply means the level of risk from a hazard you're prepared to tolerate.

You have four choices of risk tolerance using words.

I'll go through the four options first and then take a show of hands on the second run through.



Is your tolerance to the risk of being hit be a piece of satellite 'Extreme'?



Is your tolerance to the risk 'High'?

Is your tolerance to the risk 'Moderate'?

Who's prepared to tolerate a 'Low' risk of being hit by a piece of satellite?

<<No one put their hand up for Extreme or High. A few put their hands up for Moderate. More for Low.>>

And who's not sure what an Extreme, High, Moderate, or Low risk actually means?

<<This got more votes than all four of the above combined>>

Here's the thing. Whatever an Extreme, High, Moderate, or Low risk actually mean, our risk tolerance to being hit by a bit of satellite matters little because the risk is being imposed on us by the risk owner/manager, which is NASA.

We have little choice in the matter of the risk imposed on us here unless we alter our behaviour so radically it affects the quality of our lives.

As is the case with nearly all significant tree risk.

The risk to these people from tree failure in Central Park, New York is largely imposed on them by the risk owner/manager.

Those of us at risk from tree failure have little choice about the level of risk we daily encounter unless we alter our behaviour so radically…

…we move to North Dakota*.

But then we'd be forgoing the many, many benefits that trees provide.

Otherwise the risk from trees is being imposed on all of us, and the level of risk being imposed is decided by the risk owner/manager.

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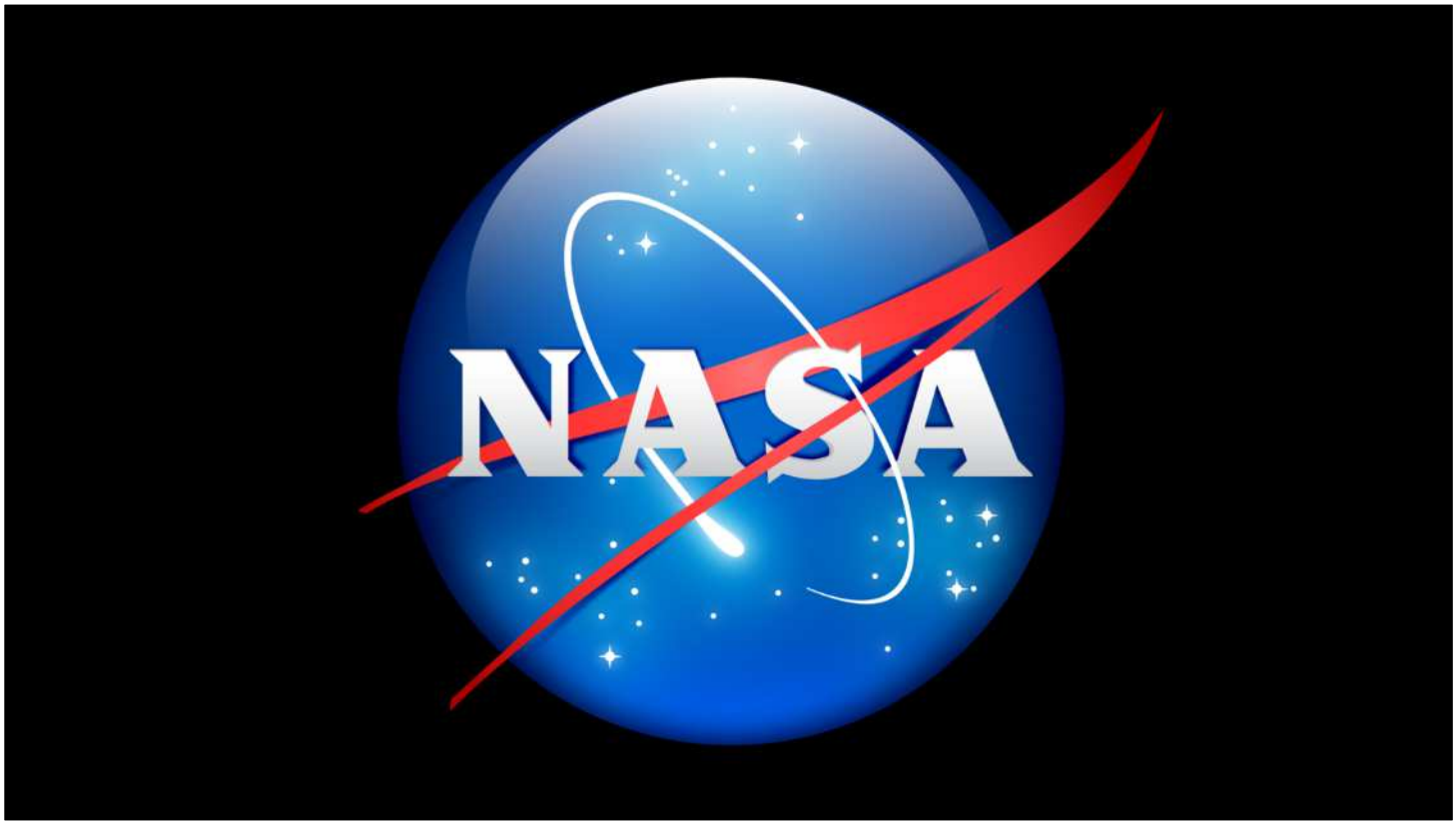
*North Dakota has the lowest percentage of urban tree cover of any state in the USA.

Meanwhile, back to the UARS' unplanned home coming in 2011.

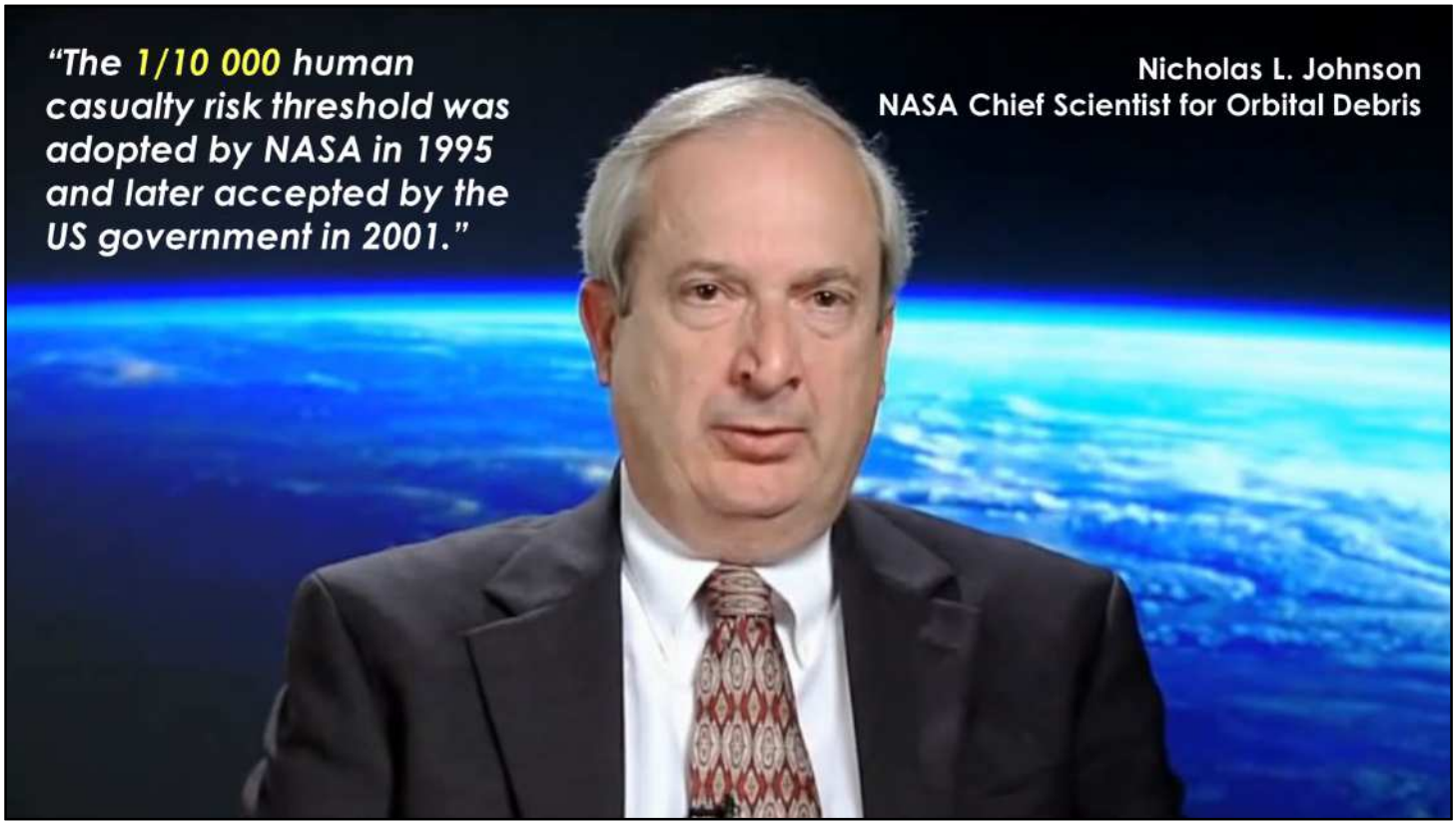
The level of risk of being hit by a re-entering bit of the UARS interested me.



So, I contacted NASA.

It turns out the level of risk that NASA imposed from the UARS is a number.

I'll reveal what the risk is as a colour, a word, and a number at the end of the presentation.



A guy called Nicholas L. Johnson, who is the Chief Scientist for Orbital Debris, kindly emailed me back.

This is what he said.

"The 1/10 000 human casualty risk threshold was adopted by NASA in 1995 and later accepted by the US government in 2001."

An imposed risk on anyone in the world of 1/10 000 is FEDERALLY endorsed.

"Recently the U.S. launch ranges have increased their accepted risks to 1/10,000 per launch."

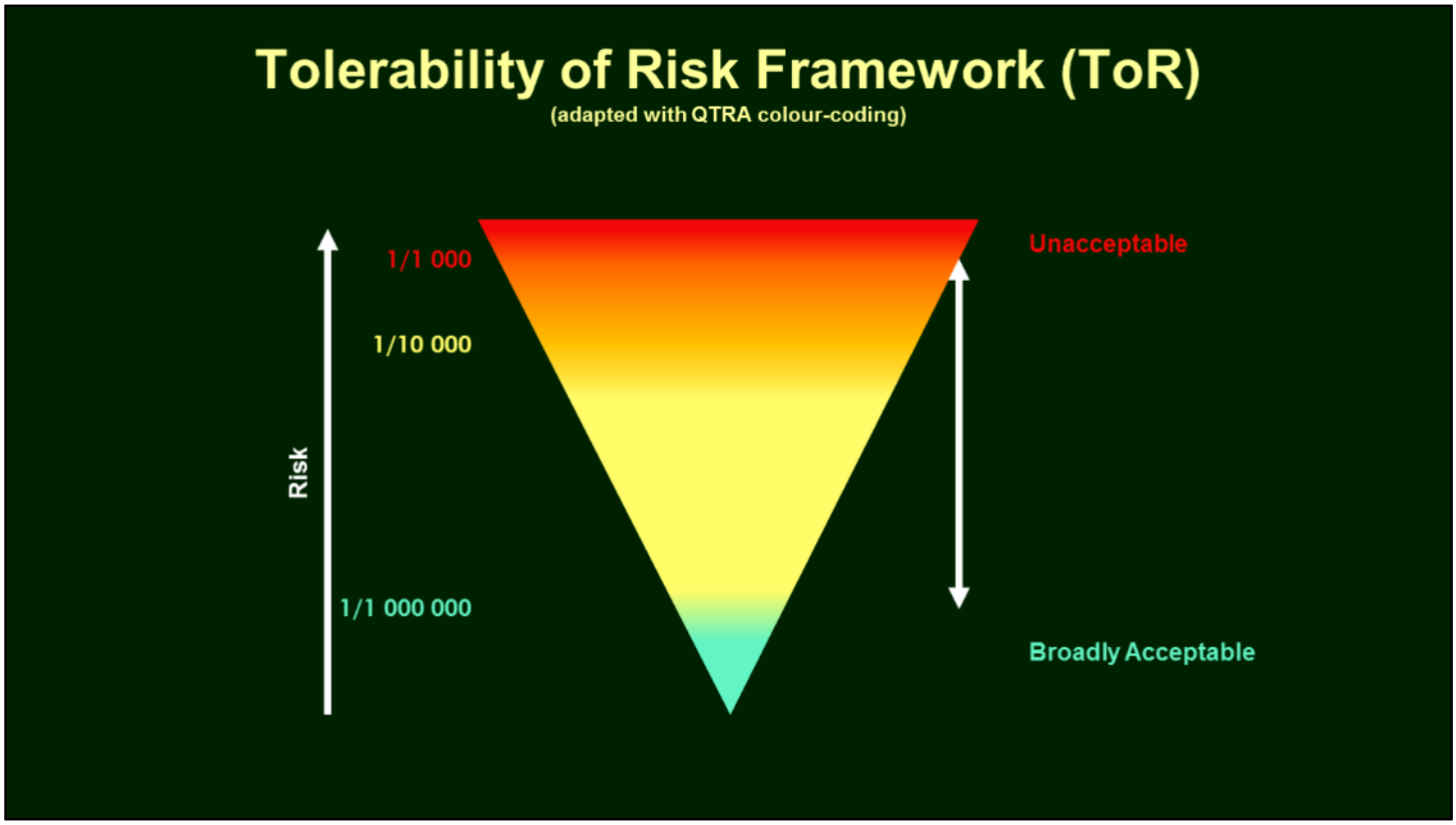
Risk from launches has been INCREASED to 1/10 000.

The Chinese, European, Indian, Japanese, and Russian space agencies have all signed up to the same protocol.

It's unknown what level of risk…

…the North Korean…

…or Iranian space agencies impose on the rest of us.



Where does the number 1/10 000 come from?

A level of risk that can be imposed by NASA on anyone in the world.

A 1/10 000 level of imposed risk comes from the widely accepted and internationally acknowledged risk tolerance thresholds established in something called the Tolerability of Risk Framework; known as 'ToR' for short.

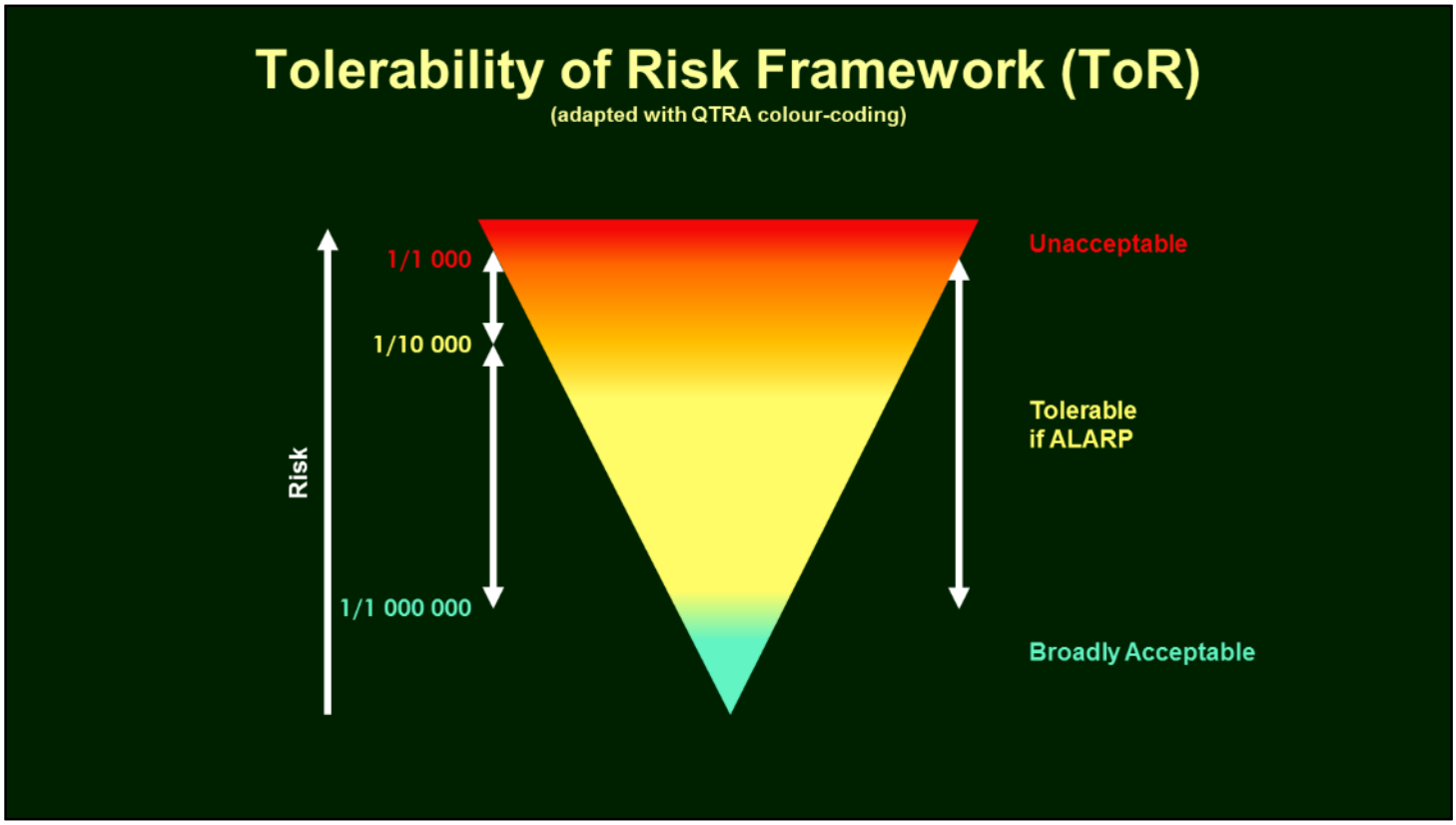
The research behind ToR was undertaken by risk experts who have probably forgotten more about risk than I'll ever know.

The reason for the shape of the triangle is it gets fatter as the risk increases, and this indicates that effort and resources to assess and manage the risk should also increase.

ToR is constructed on a foundation of numbers, which clearly and unambiguously define what the risk words mean.

A risk less than 1/1 000 000 can be regarded as Broadly Acceptable.

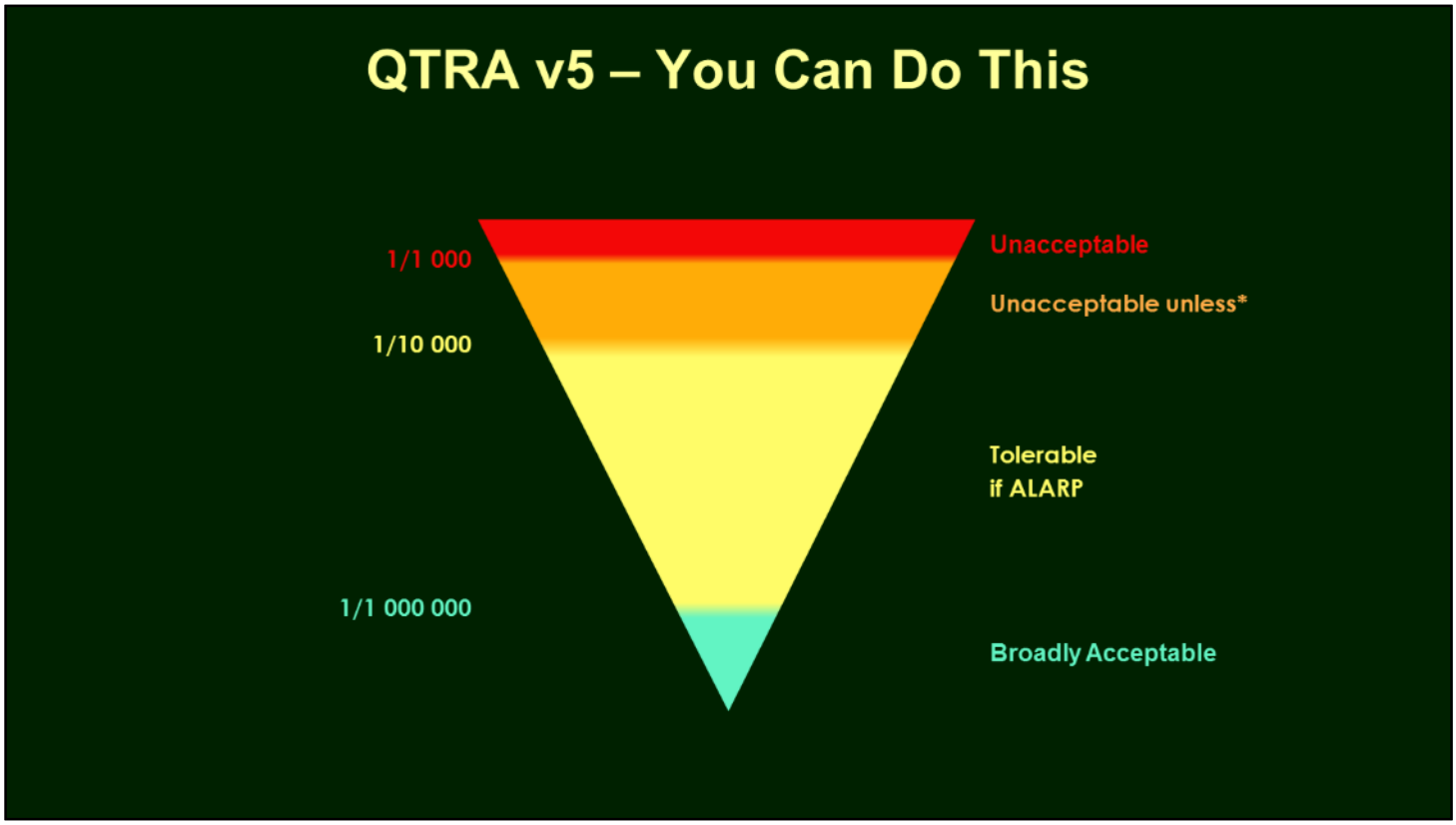
A risk greater than 1/1 000 can be regarded as Unacceptable.



A risk between 1/1 000 and 1/1 000 000 can be Tolerable if it is As Low As Reasonably Practicable (ALARP).

A risk of up to 1/10 000 can be imposed on public *'in the wider interest of society'*; where there are benefits attached to the risk, and the risk is ALARP.

A risk between 1/1 000 and 1/10 000 might be tolerable where there are exceptional benefits, or those at risk are prepared to accept the risk, and the risk is ALARP.



What Quantified Tree Risk Assessment (QTRA) proposes is the risk owner/manager adopt ToR risk tolerance thresholds for the risk they impose from their trees.

QTRA is designed to enable the risk assessor to calculate the risk so the owner/manager can compare it to the ToR risk tolerance thresholds.

In QTRA v5 the risk is expressed as;

Easy to identify traffic-light themed colours (as colour blind friendly as they can be).

We lead with the colour first.

Then the word.

And then the number that clearly defines what the colour and word mean without the 'impediment of ambiguity'.

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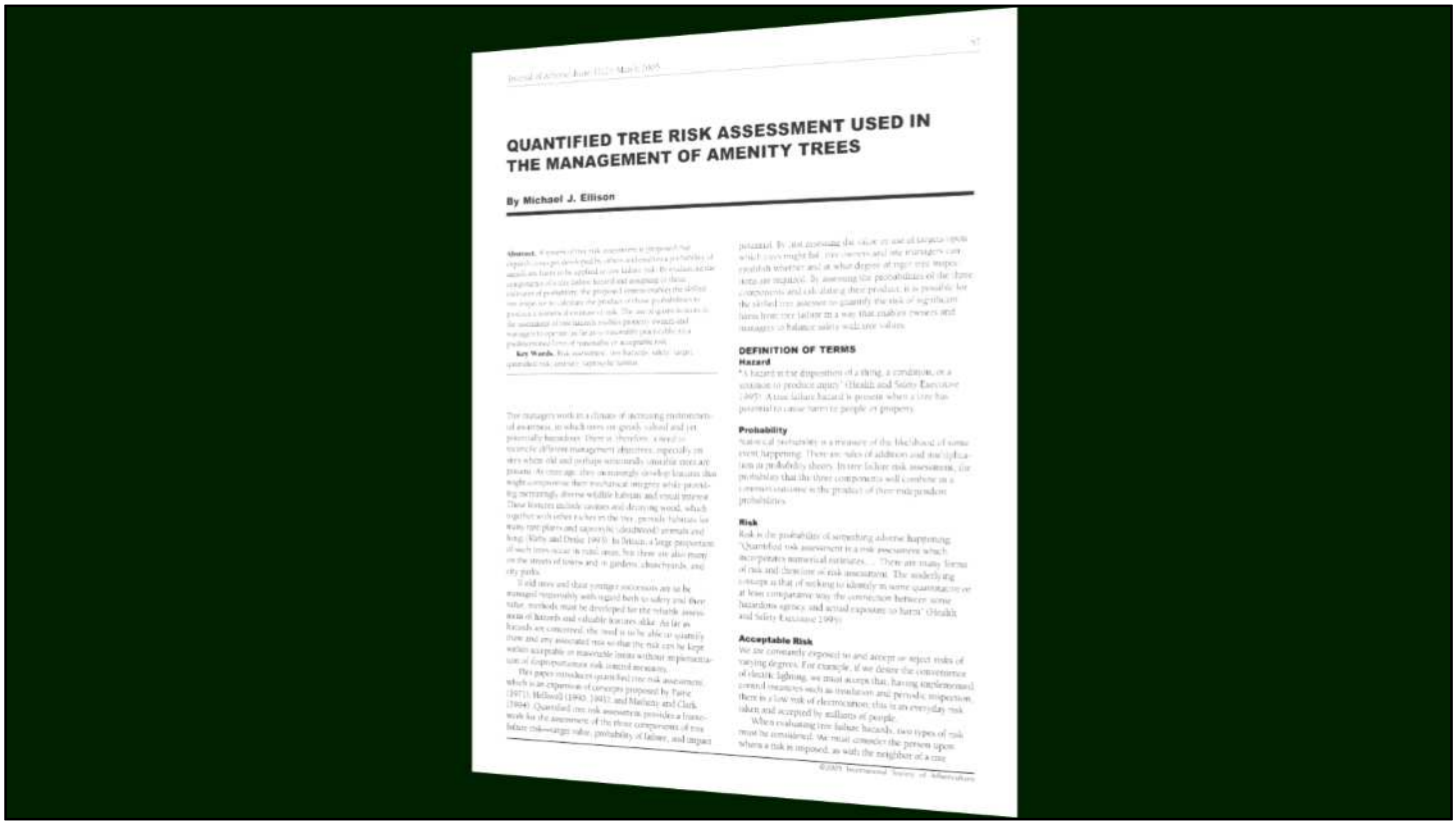
*'Unacceptable unless' is used throughout this presentation as shorthand for the QTRA Amber region. See the added 'Advisory' slide on p.36 for an expanded explanation of the Amber region.



QUANTIFIED TREE RISK ASSESSMENT USED IN THE MANAGEMENT OF AMENITY TREES

By Michael J. Ellison

With v5, QTRA has undergone its first major development since the original appeared in the ISA Journal, in 2005.

A substantial part of the development is a more sophisticated, robust, and 'risk aware' method of working out the risk that is built into the calculators, which I'll explain later.

The other progress has been the improved training and support.

Both are ongoing – in particular estimating Probability or Likelihood of Failure guidance.

Since 2005, there have been two high profile failures in the application of QTRA.

The first was a civil court case in the UK widely known as 'Poll'. In 'Poll' the experts for the Claimant and Defendant did not undertake QTRA training, made fundamental and transparent errors in the risk inputs, and consequently gave the court a misleading risk output which looks like it affected the Judgment.

Poll v Viscount Asquith of Morley (Bartholomew), Documents 9 & 11

http://tinyurl.com/c7gevwg

Or search, "QTRA Case Law Poll"

ISA

Review of QTRA and Risk-based Cost-benefit Assessment of Tree Management

Mark G. Stewart, Deolga O'Callaghan, and Mark Hartley

The second high profile case of failure in application of QTRA occurred in a Newcastle in New South Wales, Australia.

In this case, contrary to training guidance, a very precise Probability of Failure was based on a questionable reported failure rate for an important avenue of Fig trees in Laman Street during an exceptionally powerful storm named 'Pasher Bulker' in 2007.

Consequently, an unrealistic level of risk was then calculated for the remaining trees in 2009.

What is often overlooked with 'Laman Street' is the clearly stated limitations in this QTRA report – desktop only, based on a third party reported failure rate, and the risk output related to a similar storm event in the future. Nonetheless, this was contrary to training and part of QTRA's development at the time was to try and forestall a repeat of this misapplication.

'Poll' and 'Laman Street' are two high profile occasions where there was a failure in the application of QTRA, and not in the QTRA process.

Ironically, the transparency of the QTRA process allowed the failures in QTRA application to be easily identified in both cases.

Concerns about the QTRA report were brought to the attention of Mike Ellison, who first put QTRA together, and he was commissioned to undertake a second QTRA of the Laman Street Figs in 2011. He found none of the trees to be a Red or Amber, Unacceptable level of risk greater than 1/10 000.

http://tinyurl.com/4rprey

Or search "QTRA Downloads Laman Street Figs".

A paper about the 'Laman Street' Figs, a review of QTRA, and proposing a quantified approach to tree risk, was led by an Australian engineer risk expert called Mark Stewart and published in the ISA Journal, in 2013.

For me it was a frustrating paper.

Firstly, it strongly advocated quantifying tree risk – great.

Secondly, there were some obvious factual errors in there about QTRA. This constitutes poor research of easy to access material. I would have expected these basic and obvious errors to have been picked up during the peer review. QTRA was not approached for comment on the paper before publication.

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Review of QTRA and Risk-based Cost-benefit Assessment of Tree Management

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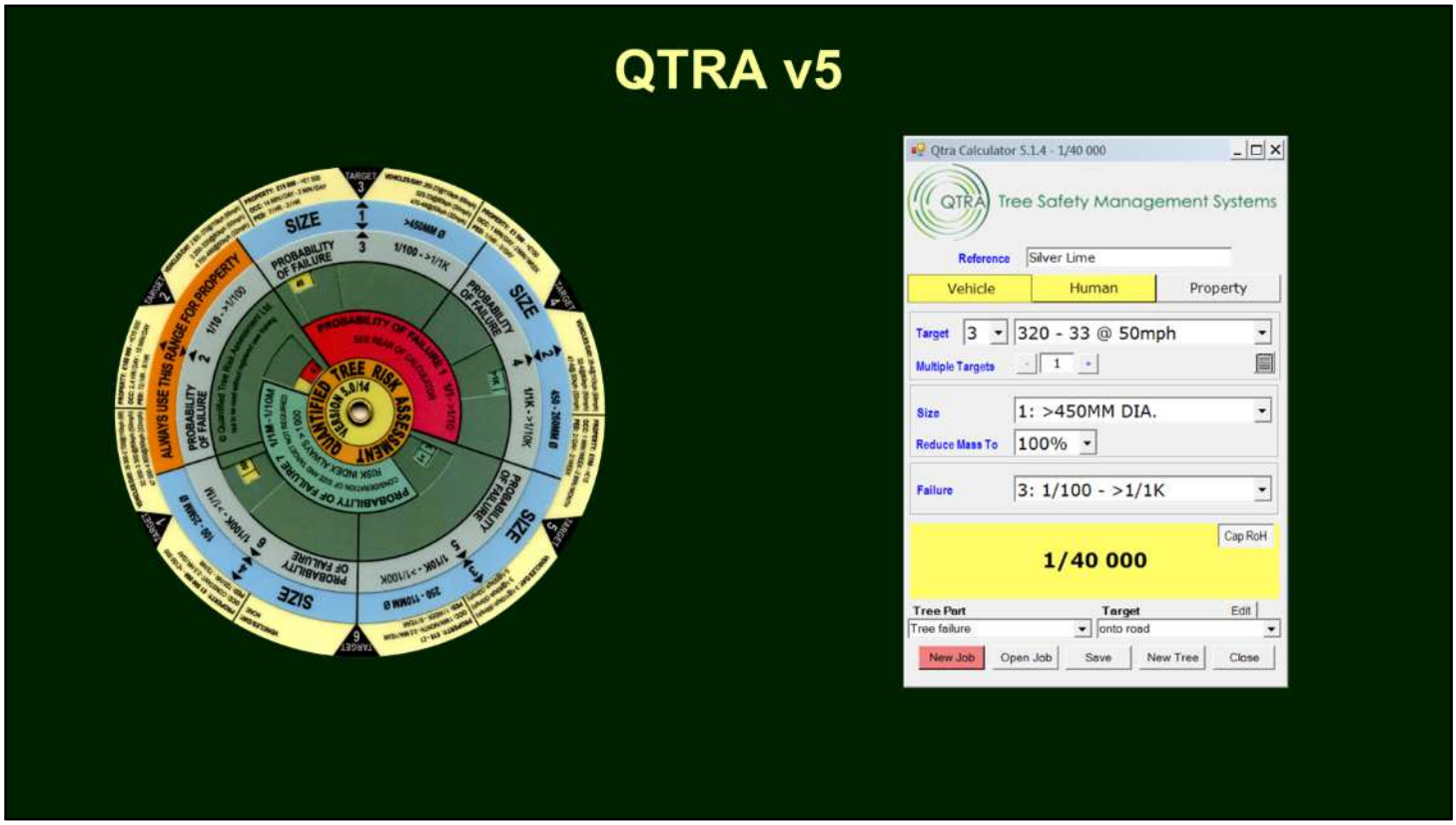
And thirdly, Mike Ellison was in contact with Mark Stewart about the failure in application of QTRA with the Laman Street Figs long before this paper was written, and had exchanged views with him about quantifying tree risk.

In 2011 QTRA was updated to take on board elements of that discussion and the 'Laman Street' lessons.

QTRA v5 was released in 2013 and addresses all of the issues raised in the Mark Stewart paper.

The Mark Stewart paper can be downloaded from the same link as above.



Here's what QTRA v5 looks like in the risk assessors hands.

There's a manual calculator – BTW I have a fistful of demonstration calculators to give away if you buttonhole me after this. They are ONLY to be used for demonstration. DO NOT use them it in the field WITHOUT training, or I'll set Lori Ballard onto you.

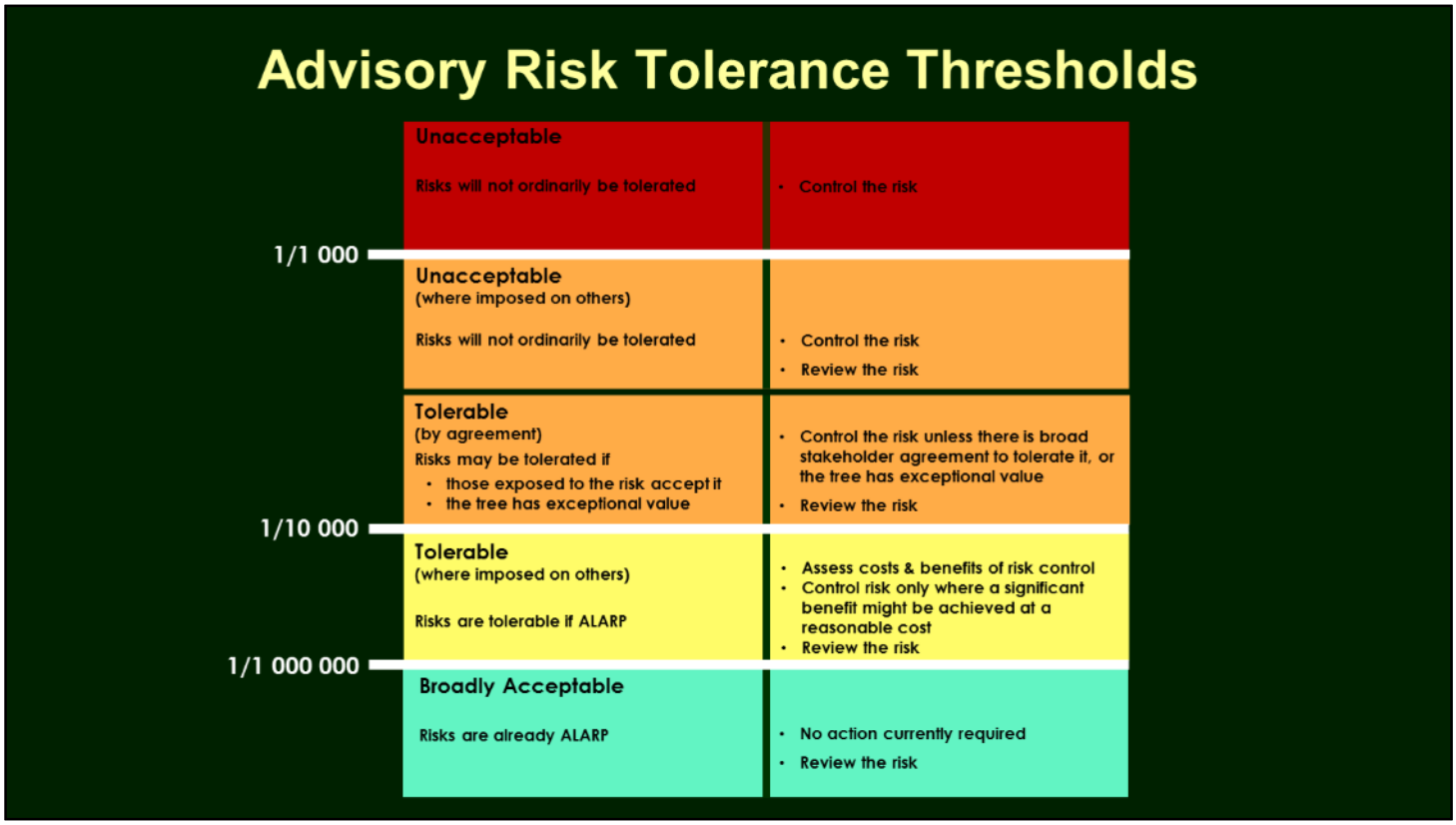
Those of you who saw Lori Ballard's great presentation yesterday will know she'll flail anyone alive she encounters who would be unwise enough to use QTRA without training, and then boil their bones for soup.

I'll be around over the next day and half to field any questions you might have.

The inputs on this one are set for a case study later, and the Yellow 40 you can see is a 'risk index'. The manual calculators produce risk indices, because of the constraints of their size, and risk indices need to have '000' added to them. A risk index of 40 is a risk of 1/40 000.

And a software calculator, where you can see the risk at Yellow 1/40 000.

These are complicated to build, but with training they are straightforward to use as I'll shortly demonstrate.



The risk assessor uses the QTRA calculator to generate a risk as a colour, word, and number.

The risk owner/manager then compares the level of risk tolerance with ToR translated into the QTRA 'Advisory', and decides what level of risk to impose. They're the ones that make the risk management decision, not the risk assessor.

Before exploring some of the main improvements and advantages to the risk assessor and risk owner/manager of using QTRA v5, I want to step back and establish some key underpinning principles about risk assessment and risk management on which everything is built.

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Slide changed from a repeated 'QTRA v5 – You Can Do This' in the presentation, to show more detail in the QTRA Risk Management 'Advisory'.

Is this tree risk management policy at Honor Park London, Risk Averse or Risk Aware?

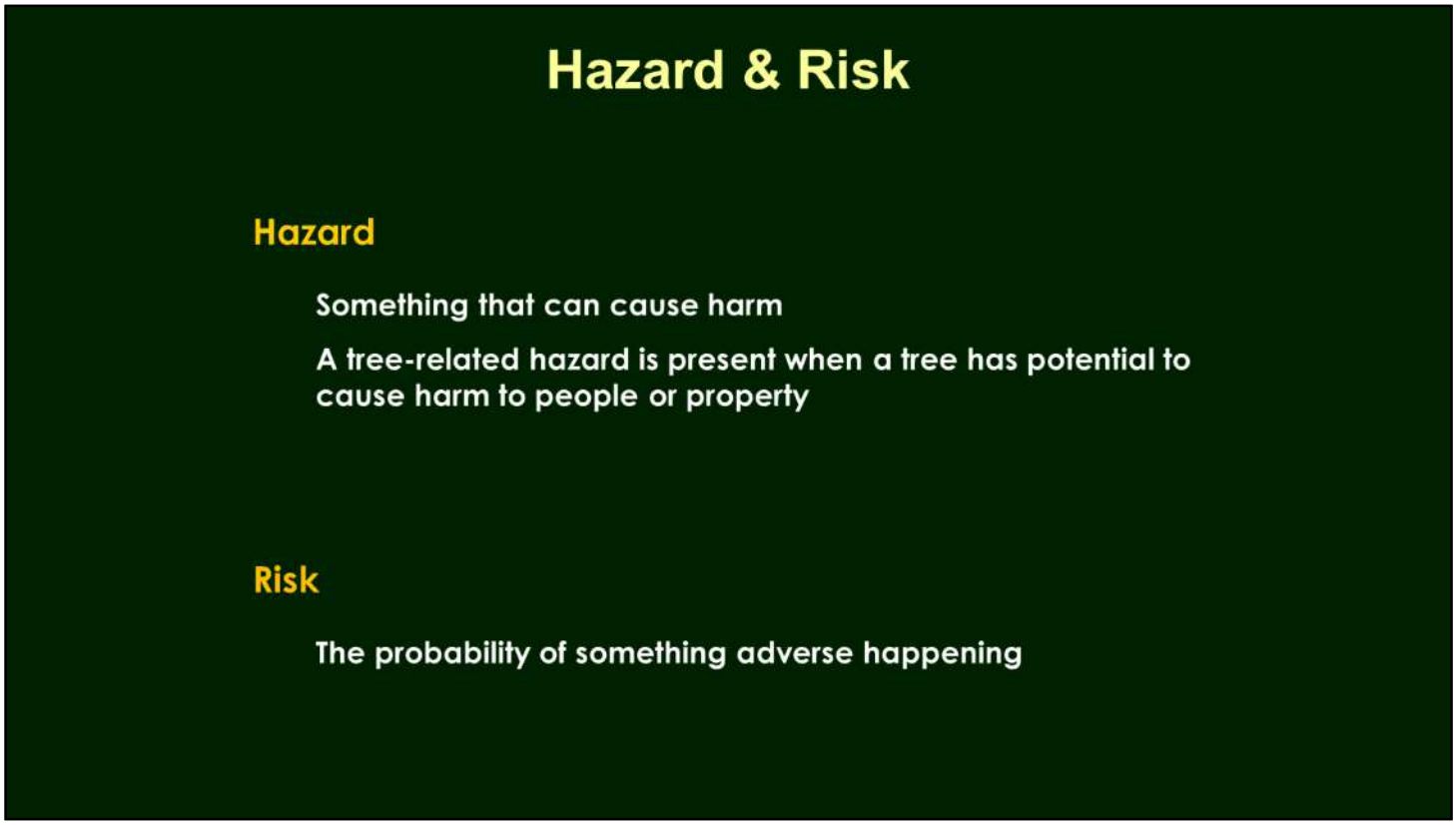
Tree risk assessment has all too often been about 'what could happen'.

As tree risk assessors, we should be looking at what is 'likely to happen', not 'what could happen'.

We should be Risk Aware and assess, 'what is likely to happen'.

Rather than be Risk Averse and speculate about, 'what could happen'.

After all, just about anything COULD happen.



Let's establish common ground with some definitions.

A Hazard is simply something that can cause harm.

Whereas, Risk is the 'probability of something adverse happening'.

Hazard assessment thinking – What could happen. There's a hazard, we need to do something about it, or eliminate it. A 'risk averse' approach.

Risk assessment thinking – What is likely to happen. There's a hazard, what is the risk from the hazard, what benefits does the hazard provide, is reducing the risk from the hazard 'proportionate'. A 'risk aware' approach.

Has anyone enjoyed a visit to Penrith train station in the UK?

There's a great example of the difference between a Hazard and a Risk there.

The Hazard is the platform edge.

The Risk is the chance of getting sucked off.

It would seem a nice day out at St. Lucia Crocodile Park in South Africa didn't go quite according to plan.

I can't help but imagine that at the bottom of this slope there's a river littered with rusting wheelchairs, and content but gap-toothed crocs.

Hazards - Slope, Wheelchair, River, and Crocodiles.

Risk – The Likelihood of being in a wheelchair, racing down the hill out of control, falling into the river, and then being snacked on by a crocodile.

To develop the theme of Hazard and Risk in relation to trees.

This is a beautiful avenue of Hazards.

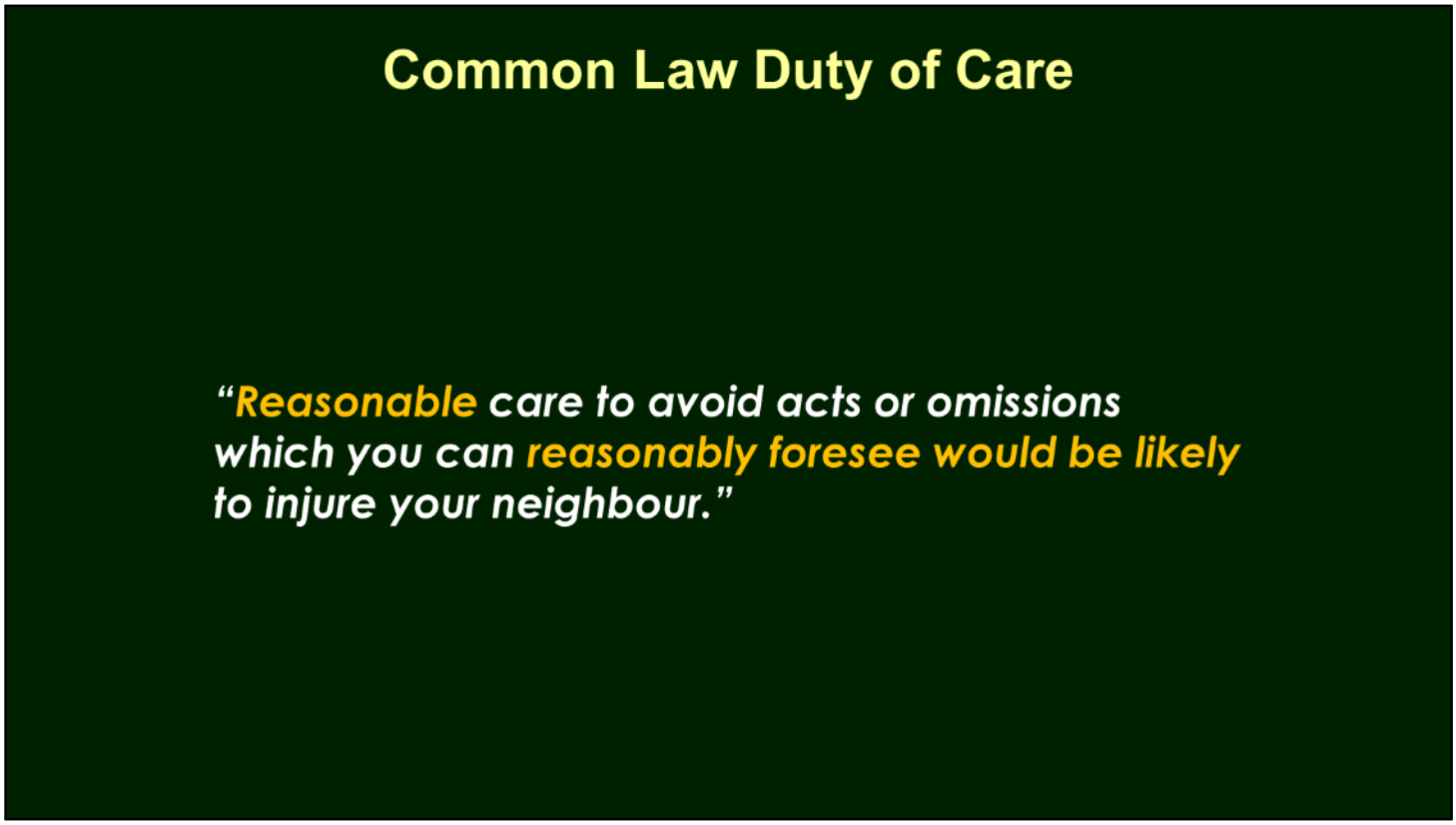
Each and every tree is a Hazard.

What does Lady Justice say about risk?

Most of us are risk assessors. It is beyond our scope to determine risk management thresholds. This is a risk owner/manager policy decision underpinned by law, and in particular primary legislation, as well as their own management priorities.

Be very wary of arboriculturists exceeding their field of expertise and claiming lower court, or court of first instance, judgments inform a duty of care. As we saw in 'Poll' earlier, the court can be hostage to the experts it gets. The court can only make a judgment based on the evidence presented to it in that particular case.

The advice about the relevance of lower court judgments by an arboriculturist could have a similar status to advice given about tree maintenance from a barrister who's done a bit of gardening.



This is UK Common Law Duty of Care, and variations on the same wording are used around the world.

"…reasonably foresee would be likely" = Probability or Likelihood.

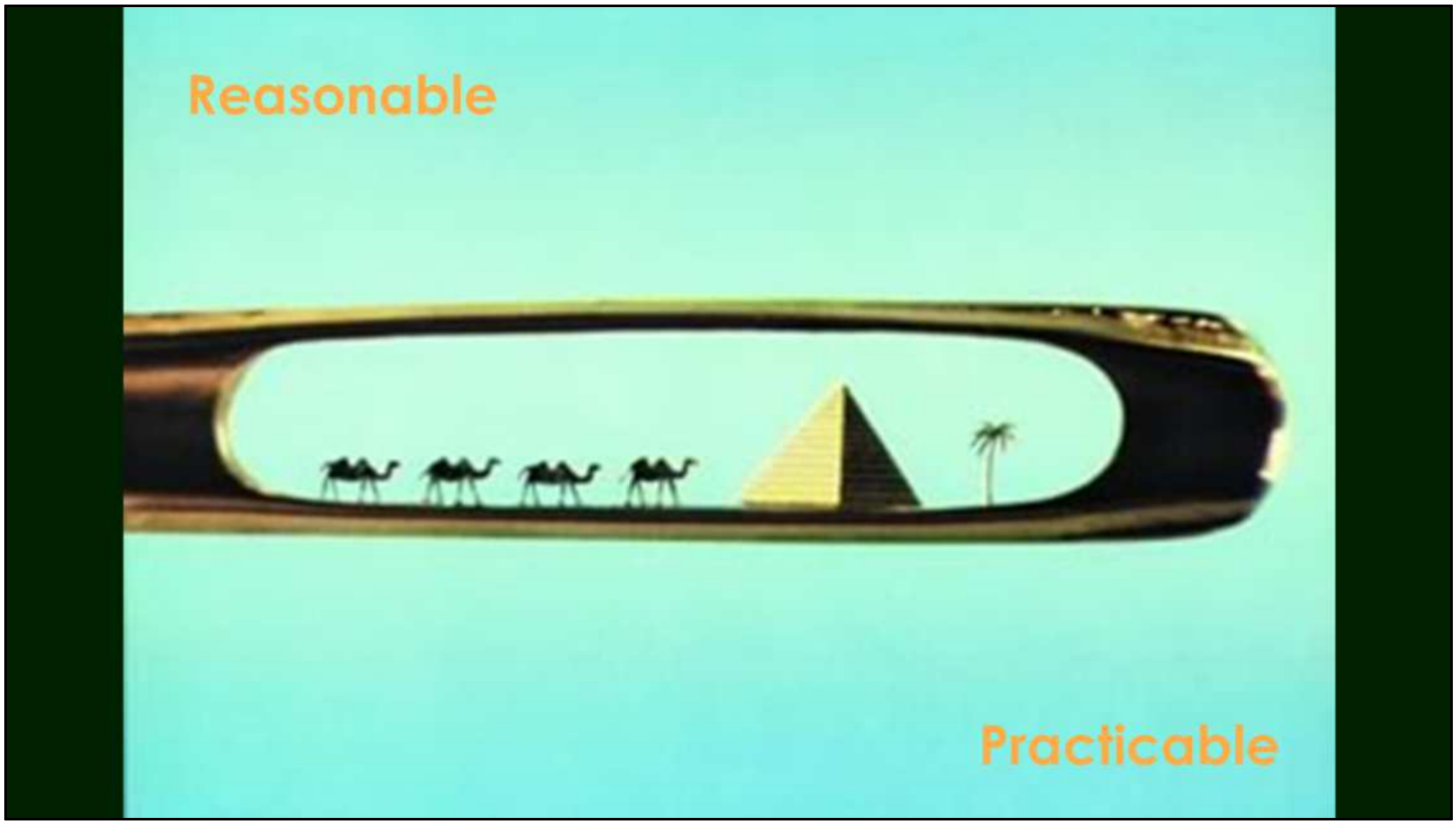
Note, the often quoted 'foreseeability' test is qualified with a 'reasonable' before and a 'would be likely' after.

The first word of the sentence starts off with a big fat, all-qualifying, 'Reasonable' – the first of two.

That's because the law is very aware it is unreasonable to expect us to assess risk with this level of yes/no, binary certainty that comes from taking 'foreseeability' in isolation.

If an expert says something was 'foreseeable' after the event, then in terms of probability – *'reasonably foresee would be likely'* - they are saying they would have assessed the risk at 1/1 beforehand. This is such an incredibly precise and accurate level of risk assessment from the likelihood of a tree failing, the likelihood of someone or something being there, and significant consequences being caused, it's simply not credible.

Those who claim to be blessed with such certain 'foresight' after the event are all too often afflicted by 20/20 'hindsight bias'.

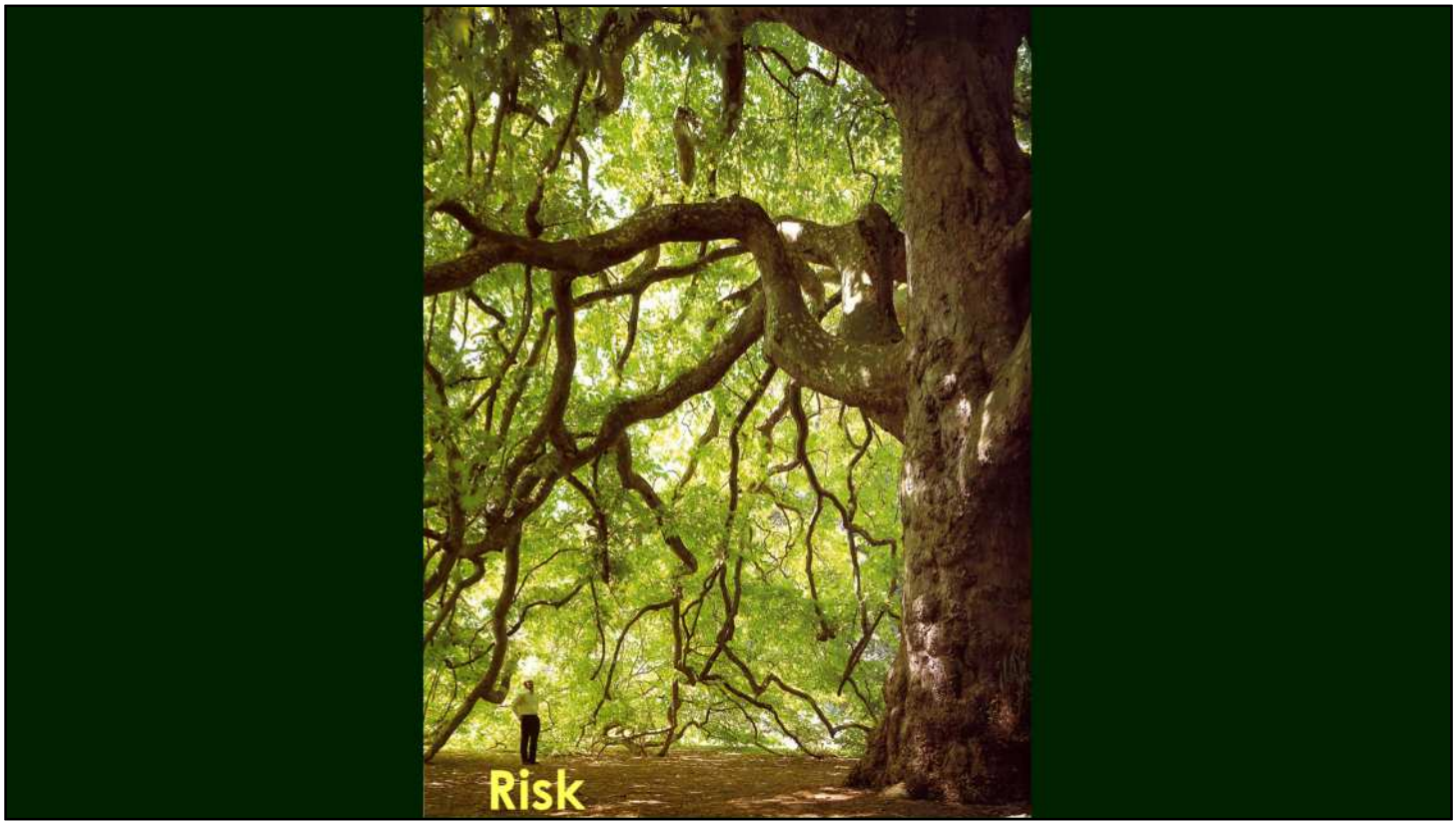


The Law asks that we be 'reasonable' in managing risk, and that we also be 'practicable'.

Reasonable Practicability is the Rosetta Stone of risk management.

What 'reasonable practicability' asks is that with the assessment and management of the risk associated with a hazard (tree), the aim is to maintain that risk at a reasonable level, whilst maximising the benefit derived from the hazard (tree), and only reduce the risk if it is cost-effective and proportionate to do so.

We need to consider three elements;

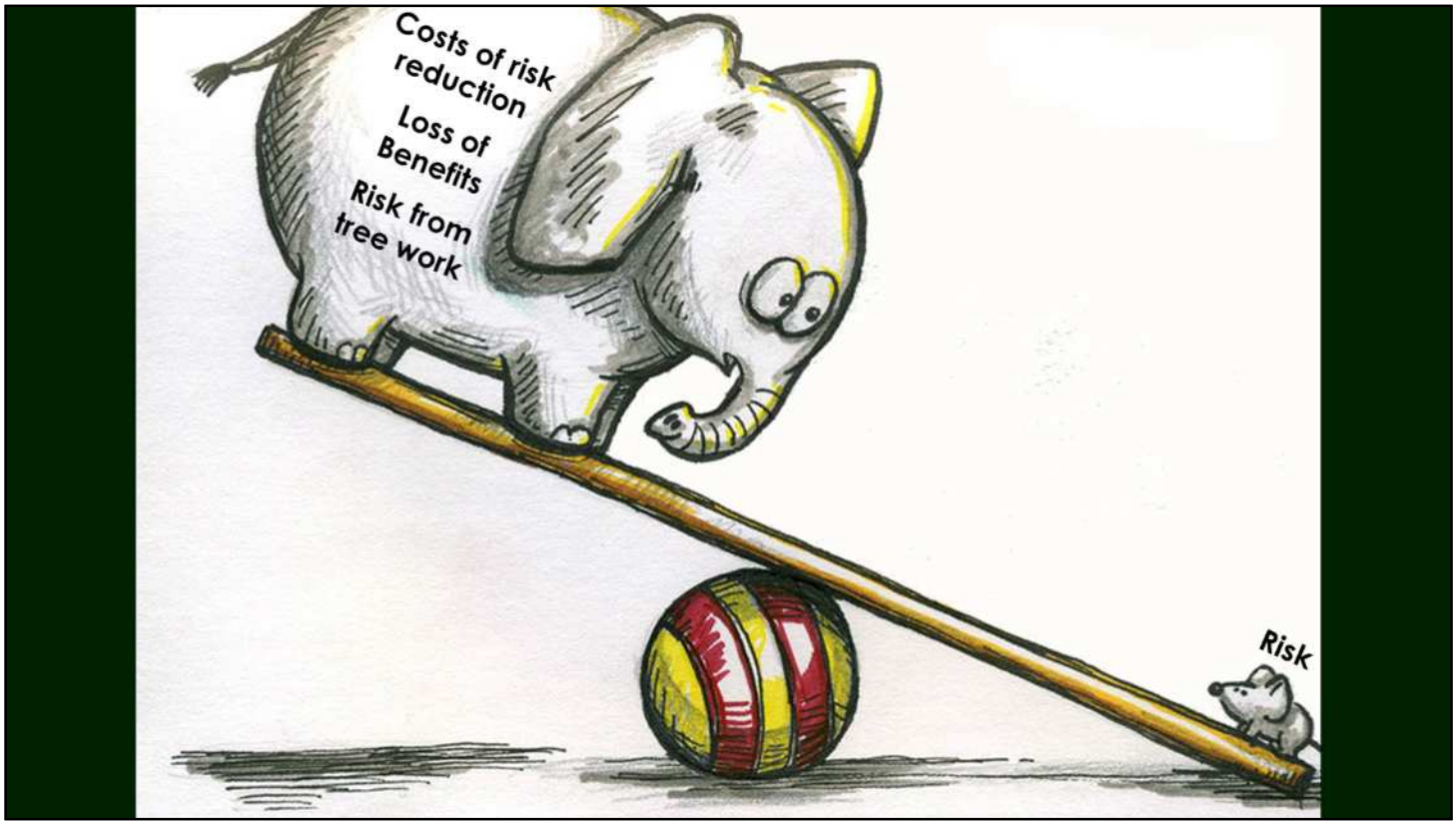


The risk from the tree.

The many environmental and psychological benefits that trees provide.

The costs of the tree work to mitigate and reduce the risk.

And the 'risk transfer' to those doing tree work and passers-by.



The principle of 'reasonably practicability' asks that we balance risks with the costs and benefits.

By only considering the rodent of risk we will have an unbalanced and biased approach to risk assessment and risk management.

We also need to consider the costs of reducing the risk, the benefits lost, and the risk transfer.

We shouldn't be ignoring the elephant in the room. We should be trying to weigh it.

Otherwise, tree risk management can all too easily become a 'risk averse' and disproportionate, tail-chasing exercise, where there is often a lower level of risk that could be achieved, with no regard to how much it might cost the risk owner/manager, and what tree-related benefits would be lost.

To not consider ALARP is to be 'risk averse' and worship at the unattainable altar of complete safety, no matter what the cost is to the owner/manager or the environment.

Finally, how do we assess risk?

Risk = Likelihood x Consequences (ISO 31000:2009 Risk Management - Principles and Guidelines)

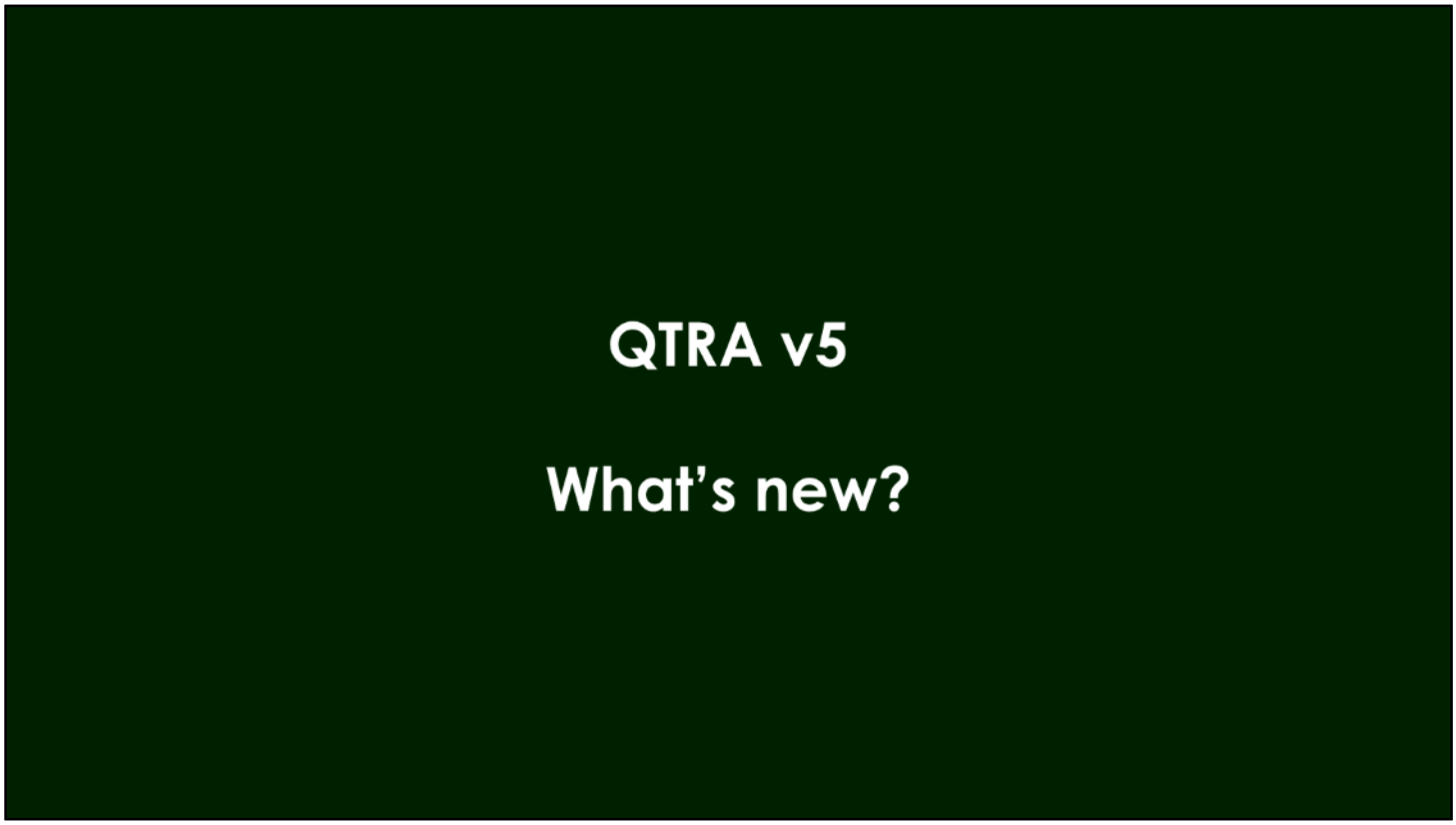
The 'x' is really important whether you're using a quantitative or qualitative approach to risk because we are looking at independent probabilities and their relationship is multiplicative.

The easiest way to explain this relationship is that if, all other things being equal, we have twice as many people pass under tree as before, then the risk is now twice as high.

If there are half the number of vehicles on the road as before, then the risk is now half of what it was.

The risk doubles or halves here, irrespective of how hazardous the tree is.

These are truths we can hold to be self-evident.



You've had a glimpse of the new calculators.

One of the first changes in v5 are the Target ranges. There are still six of them for Property, Humans, and Vehicle Traffic…

Target Ranges

Target Range	Property (repair or replacement)	Human	Vehicle Traffic (per day)	Target Value
1				1/1 - >1/10
2				1/10 - >1/100
3				1/100 - >1/1 000
4				1/1 000 - >1/10 000
5				1/10 000 - >1/100 000
6				1/100 000 - 1/1 000 000

…but they are now in broad x10 ranges

I'll save your eyes a data dump for Humans and Vehicle Traffic and just reveal the Property ranges in US dollars.

More detail is available in the QTRA Practice Note.

http://tinyurl.com/nlpge5p

Target Ranges

Target Range	Property (repair or replacement)	Human	Vehicle Traffic (per day)	Target Value
1	$2 400 000 - >$240 000			1/1 - >1/10
2	$240 000 - >$24 000			1/10 - >1/100
3	$24 000 - >$2 400			1/100 - >1/1 000
4	$2 400 - >$240			1/1 000 - >1/10 000
5	$240 - >$24			1/10 000 - >1/100 000
6	<$24			1/100 000 - 1/1 000 000

These Targets are in broad ranges. With a bit of thought and training it is relatively easy to work out which Target range to input. You need no knowledge of trees to do this part of the risk assessment.

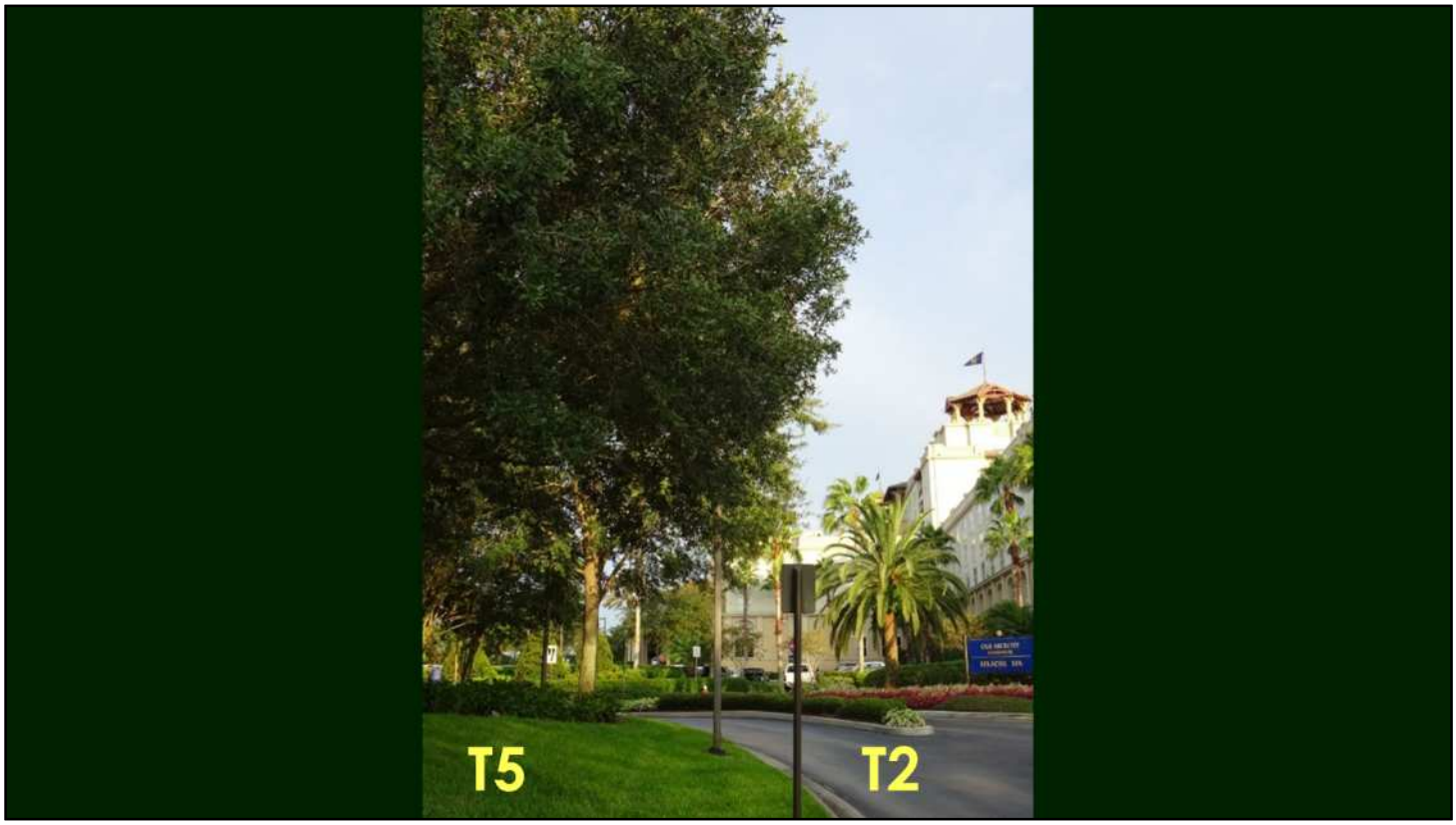
The risk assessor, with little consideration, will be able to figure out that four of the Target ranges are usually stupid and they are left with two to consider.

Which Target range is chosen is usually pretty obvious once you get some experience under your belt and learn to ask the risk owner/manager (who usually knows how the site is used better than you) the right questions.

If there's uncertainty between the two Target ranges, and it's going to take a lot of time and effort to work it out, then they simply choose the higher range.

To show you how easy it is use, I escaped from the Gaylord Palms compound yesterday and took a few minutes to assess some of the Target ranges.

Here's one of the main roads, which is Target range 1.



I asked at reception and there are 1 400 beds in the hotel.

Often these beds are shared by more than one person.

And occasionally by even more.

Naturally, no one walks into the place, so the entrance road is vehicle traffic and Target range 2.

All the landscaped areas outside of the main hotel are not used recreationally. Their purpose is to frame the resort and perhaps provide a clear field of fire.

They are 'weather-affected' targets and are Target range 5.

An unoccupied vehicle in a car park is nearly always Target Range 3.

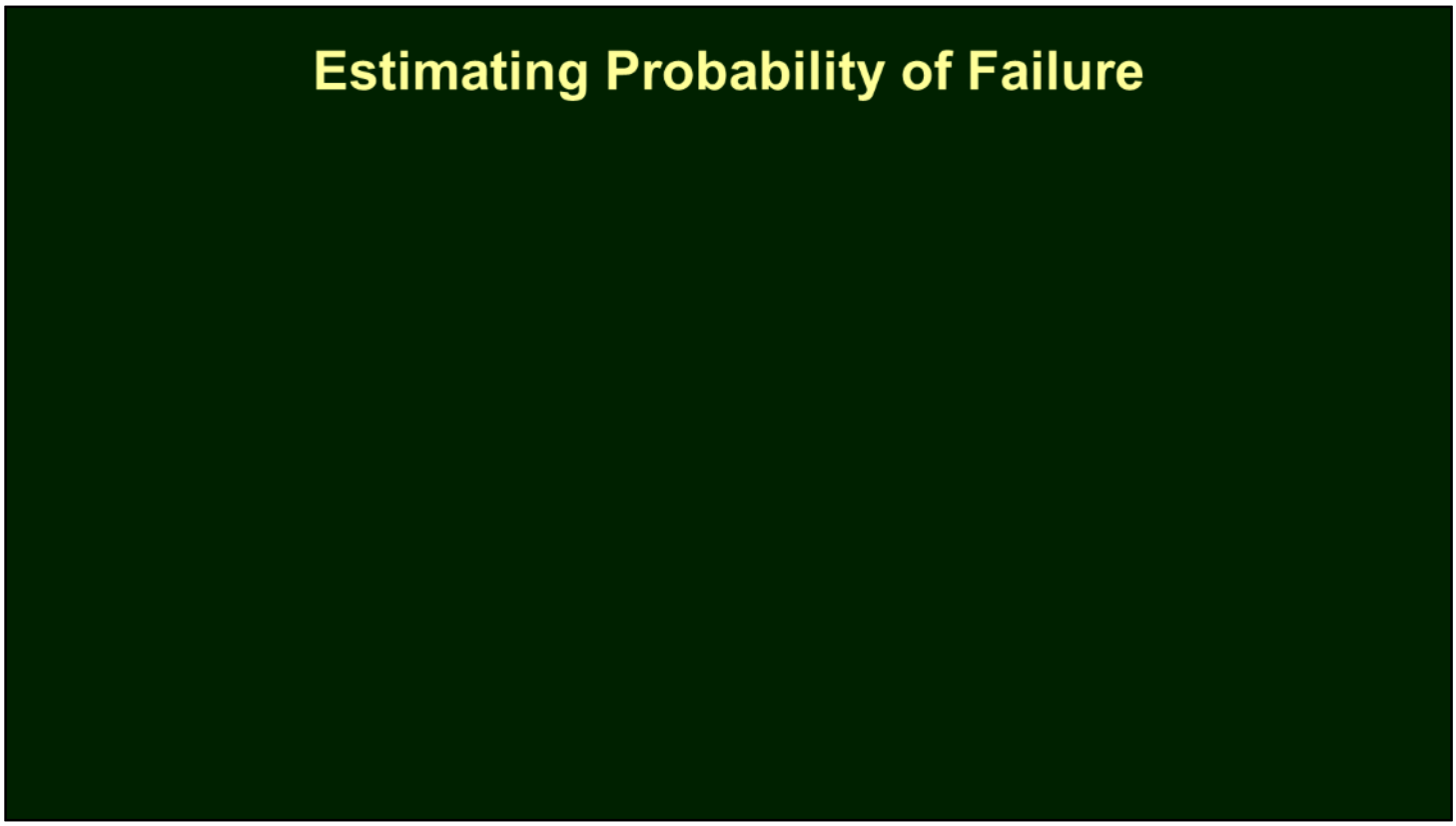
Expensive cars on private drives can be Target range 2

Target Ranges

Target Range	Property (repair or replacement)	Human	Vehicle Traffic (per day)	Target Value
1	£1 500 000 - >£150 000	Occupation Constant – 2.5hr/day Pedestrians & Cyclists 720/hr – 73/hr	26 000 – 2 700 vehicles @ 110kph (68mph) 32 000 – 3 300 vehicles @ 80kph (50mph) 47 000 – 4 800 vehicles @ 50kph (32mph)	1/1 - >1/10
2	£150 000 - >£15 000	Occupation 2.4hrs/day – 15min/day Pedestrians & Cyclists 72/hr – 8/hr	2 600 – 270 vehicles @ 110kph (69mph) 3 200 - 330 vehicles @ 80kph (50mph) 4 700 - 480 vehicles @ 50kph (32mph)	1/10 - >1/100
3	£15 000 - >£1 500	Occupation 18min/day – 2min/day Pedestrians & Cyclists 7/hr – 2/hr	260 - 27 vehicles @ 110kph (69mph) 320 - 33 vehicles @ 80kph (50mph) 470 - 48 vehicles @ 50kph (32mph)	1/100 - >1/1 000
4	£1 500 - >£1 500	Occupation 1min/day – 2mins/week Pedestrians & Cyclists 1/hr – 3/day	26 - 4 vehicles @ 110kph (69mph) 32 - 4 vehicles @ 80kph (50mph) 47 - 6 vehicles @ 50kph (32mph)	1/1 000 - >1/10 000
5	£150 - >£15	Occupation 1min/week – 2min/mth Pedestrians & Cyclists 2/day – 2/week	3 - 1 vehicles @ 110kph (69mph) 3 - 1 vehicles @ 80kph (50mph) 5 - 1 vehicles @ 50kph (32mph)	1/10 000 - >1/100 000
6	<£15 - £1	Occupation 1min/mth – 0.5min/year Pedestrians & Cyclists 1/week – 6/year	None	1/100 000 - 1/1 000 000

Additional slide showing all the Target Ranges that appear on the manual calculator.

The software calculator has a wider range of Vehicle Traffic targets at 10kph intervals which cannot fit onto the manual calculator.



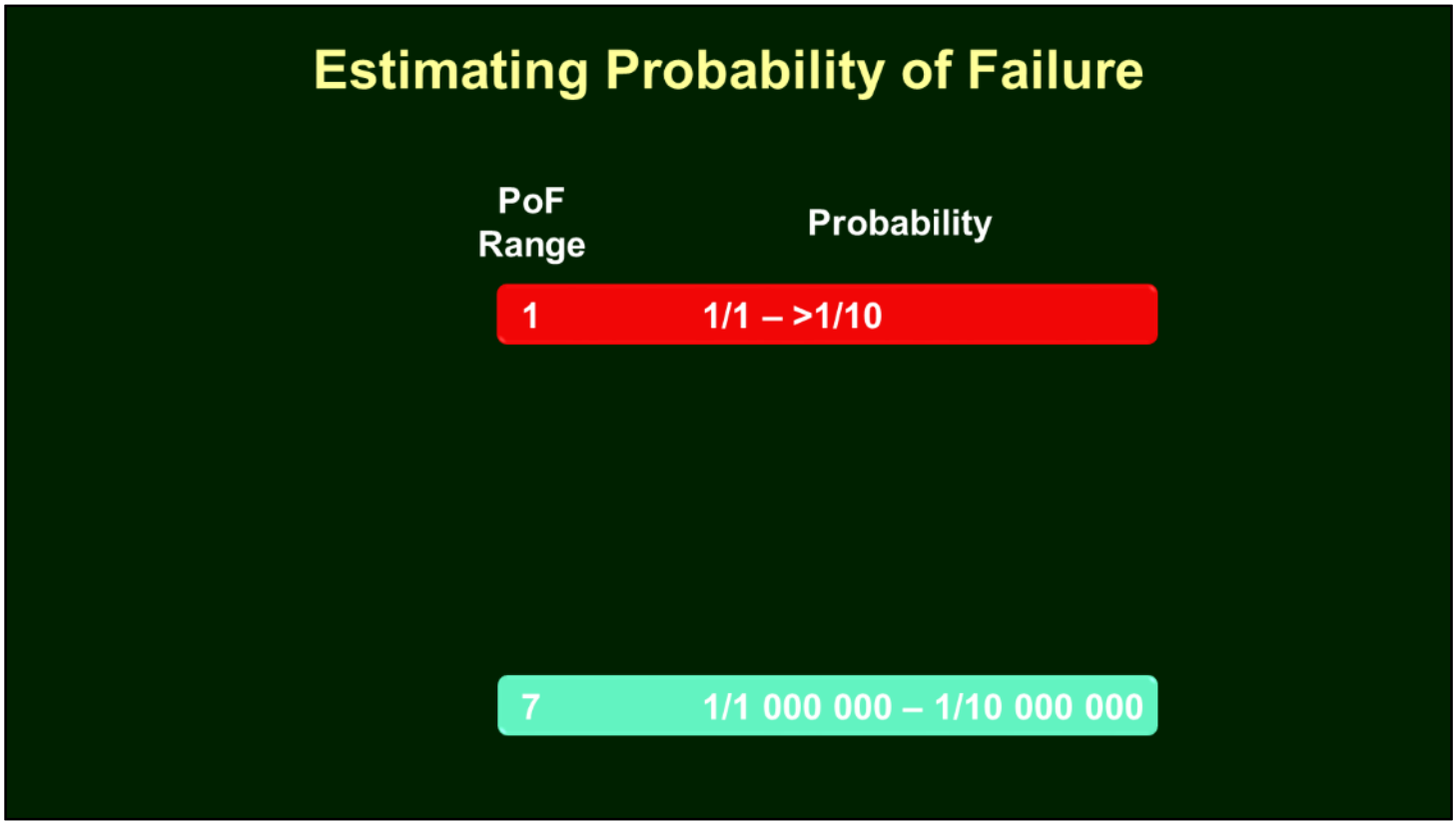
Probability, or Likelihood, of Failure is the most subjective part of a tree risk assessment.

It has the greatest level of uncertainty and is the part most dependent on the skill of the assessor.

One of the major developments in QTRA that began in 2011, following Mike Ellison's exchanges with Mark Stewart, was the use of benchmarking when estimating Likelihood of Failure.

It's still being developed and refined. I'm currently working on a mnemonic called VALID which is designed to help the risk assessor when estimating Likelihood of Failure. I'll be presenting VALID at the Arboricultural Association conference in the UK this September.

I'm going to cover this very briefly, and then show you how it works in the field calibration exercises during training.

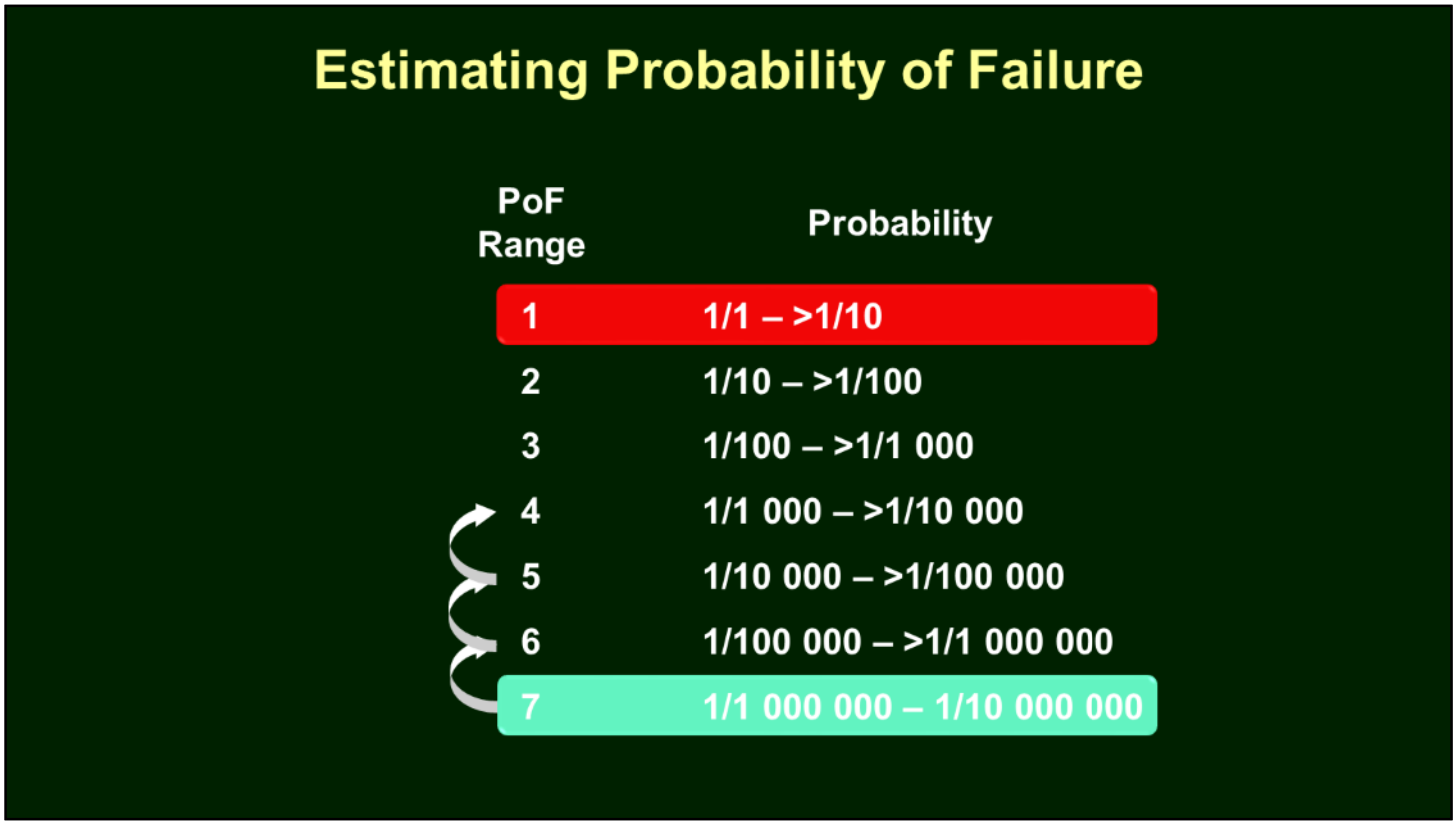


We have two benchmarks in broad ranges of x10 where we have the highest level of confidence and the lowest level of uncertainty in our estimate.

We never use exact numerical point values with QTRA. It's always a range, because we can't have such a high level of confidence to pick an exact value. We simply can't be that certain.

Benchmark Green 7 is the uncompromised tree, or one that has adapted so well we are confident it is not significantly compromised, and we expect not to fail in the next year.

Benchmark Red 1 is the tree that is so compromised we estimate it has between a certain and a tenth of a chance of failing in the next year.



There are 7 Probability of Failure (PoF) ranges. The range for each one is a factor of 10.

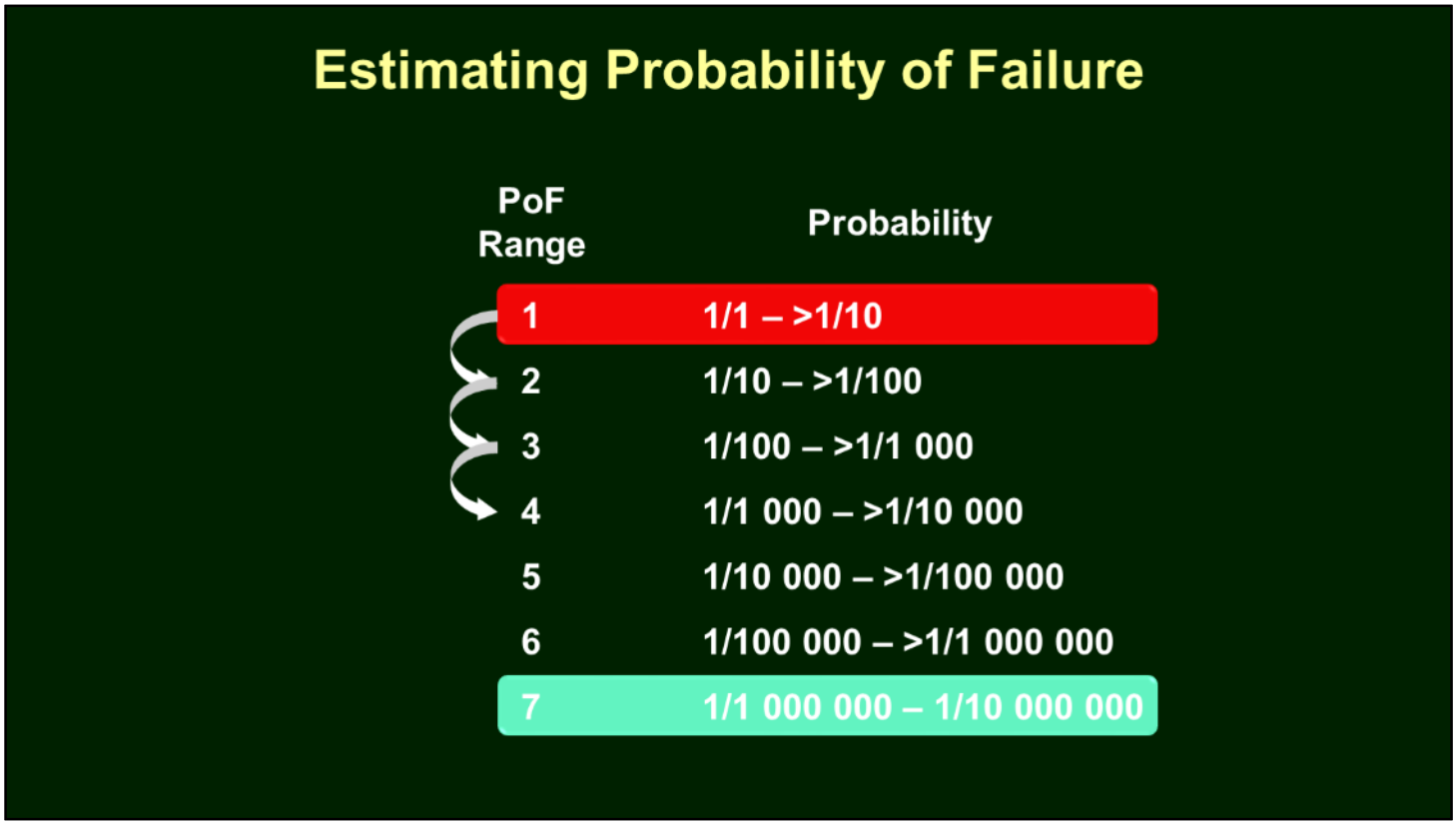
What the risk assessor does first is decide which Benchmark they anchor their opinion to.

If they choose Benchmark Green 7, then they are asked to estimate whether the Probability of Failure range is Range 7.

Or whether it's up to 10 times MORE likely to failure than the benchmark at Range 6.

Or up to a range of 100 times MORE likely to fail at Range 5.

Or up to a range of 1 000 times MORE likely to fail at Range 4.

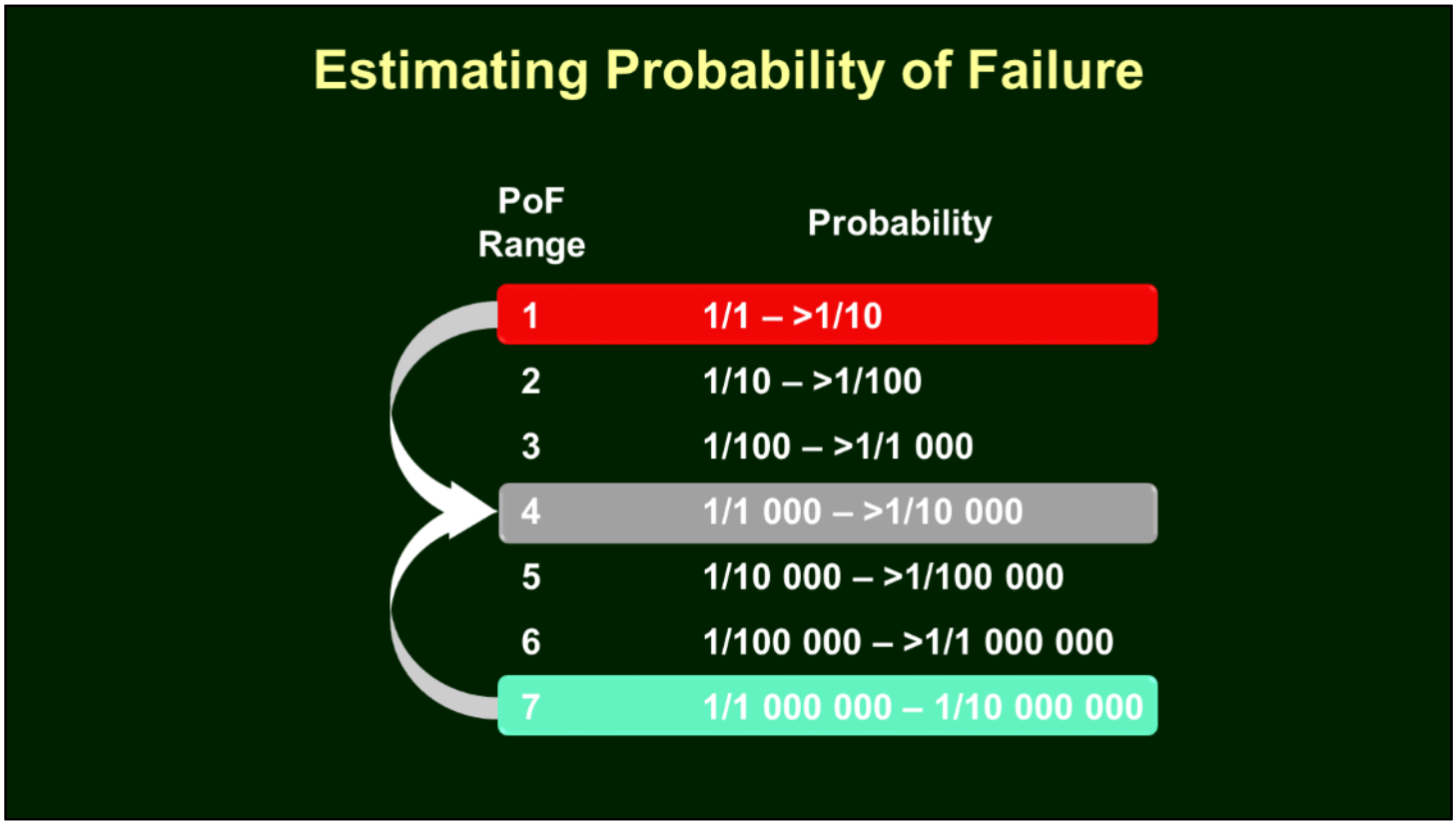


If they choose Benchmark Red 1, then they estimate whether the PoF Range is 1.

Or whether it's up to 10 times LESS likely to failure at Range 2.

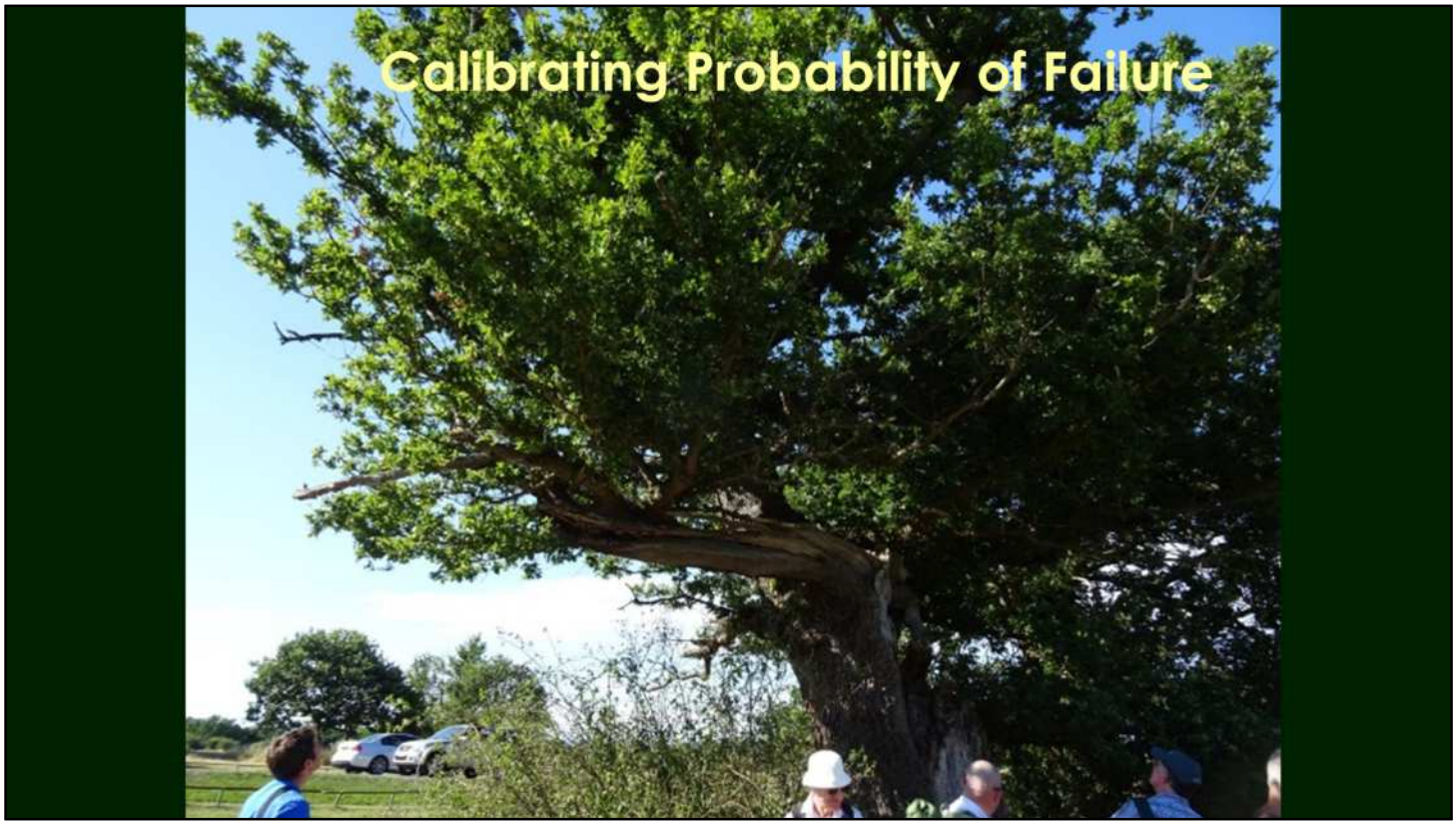
Or up to a range of 100 times LESS likely to fail at Range 3.

Or up to a range of 1 000 times LESS likely to fail at Range 4.



With each jump in range from the benchmark we have more uncertainty in the estimate.

PoF range 4 is midway between our benchmarks, the only range that can be arrived at from either benchmark, and is the range where we have the lowest confidence and highest uncertainty.



This is a re-enactment example of how calibration exercises typically run from a recent QTRA day out in Windsor Great Park, where we were calibrating Likelihood of Failure estimates, and putting VALID through some field tests.

The first rule of Likelihood of Failure Club is: You do not talk about Likelihood of Failure Club. You do not talk about your thoughts until the third round of voting.

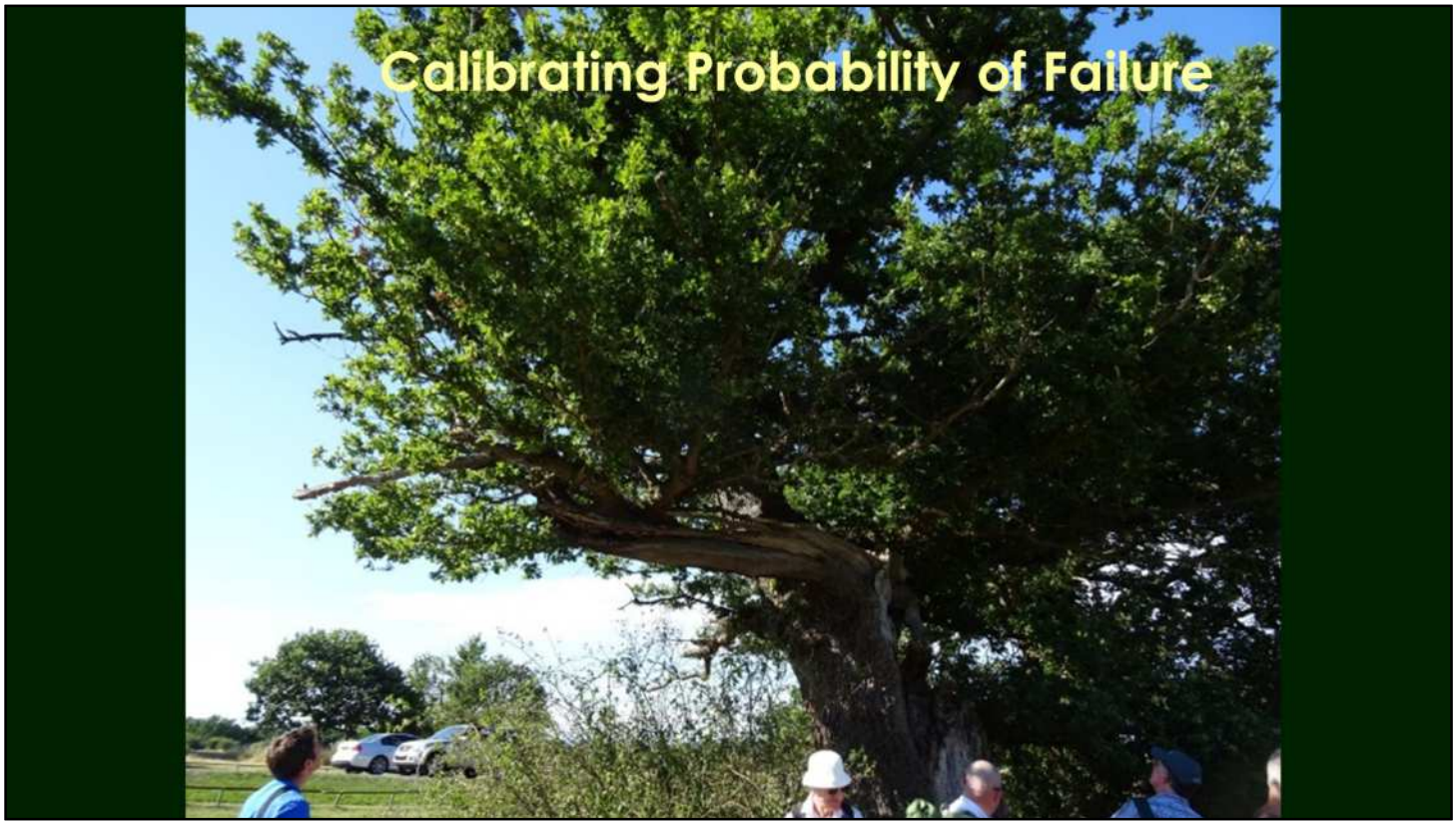
In this case we have a first order branch with a column of long-standing decay on the tension wood side.

You form an independent opinion about which Benchmark you're going to anchor your estimate to and do not discuss this with anyone else.

Then you choose which PoF range you're going for.

We take a first vote on the benchmark selected, and then a second vote on the PoF range.

After the opening opinions have been declared, and the members of each PoF range estimate have been revealed, those who have voted for one PoF range are invited to explain the reasoning behind why they have chosen that range. They then try and persuade those in the other range to join them. And vice versa.



The VALID components. Vitality, Anatomy, Load (wind), Identification (species), and Defect are gone through to help inform the debate and the decision making process.

We then take a third vote after the discussion and explain that changing your mind when presented with additional evidence in VALID, that perhaps you hadn't given full consideration to during the first and second vote, is a good thing.

After the third vote, I come in with my union block vote and tell them which range I would go for.

I tell them that between 80-90% of those that have attended QTRA and 'Visual Tree Assessment – Estimating Likelihood of Failure' training would choose this range.

I'm very fortunate. I'm in a really privileged positon to have benefited from the opinions of well over 1 000 arborists during QTRA training since this approach was taken to estimating Probability of Failure. Part of my role as a trainer is to pass that shared knowledge on to others, and learn from them.

This is what it looks like.

The first vote has all 11 agreeing to anchor their opinion from Benchmark Green 7.

2 go for PoF range 6.

9 go for PoF range 5.

After consideration of VALID, and a healthy debate, eventually all 11 agree on PoF Range 5.

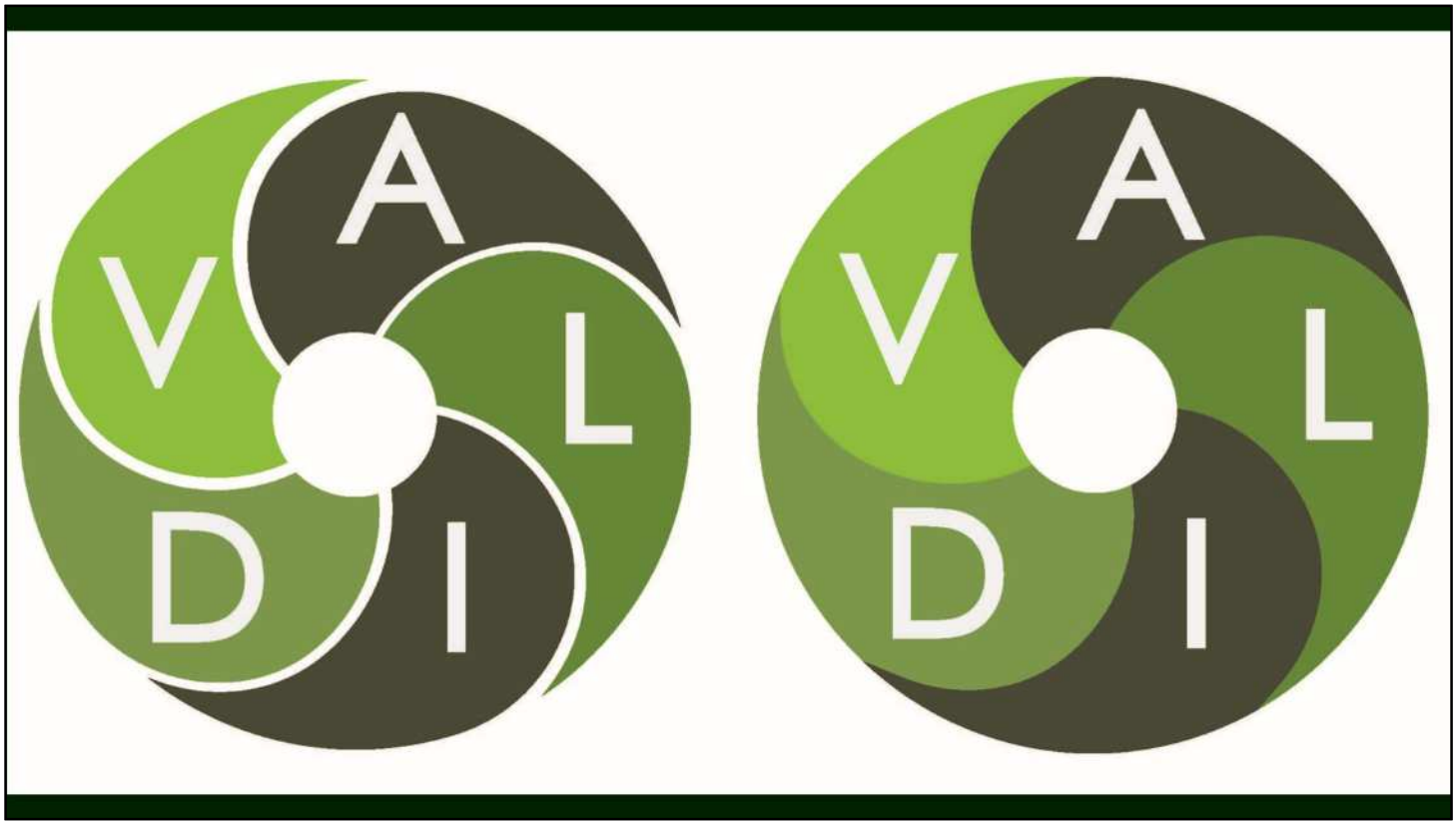
Generally, 80-90% will park their opinion in the same range.

The other 10-20% will be in the next PoF range.

What QTRA is doing here is providing a Probability of Failure framework, in numerical ranges, that converts guided subjective PoF estimates with a high degree of consensus and consistency.

This translation to numbers enables the risk assessor to calculate a level of risk which the owner/manager can compare with the risk tolerance thresholds in ToR.

Estimating Probability of Failure is such an important part of the risk assessment process, QTRA training is paired with a 'Visual Tree Assessment – Estimating Probability of Failure' day. On that day, the focus is on the underpinning tree biology, pathology, and biomechanics that can affect tree stability, and many of these calibration exercises out in the field.



Here's a some of the early drafts of what the VALID logo might look like.

One of the most important developments to the engine of QTRA v5 is the use of Monte Carlo Simulations to calculate the risk outputs.

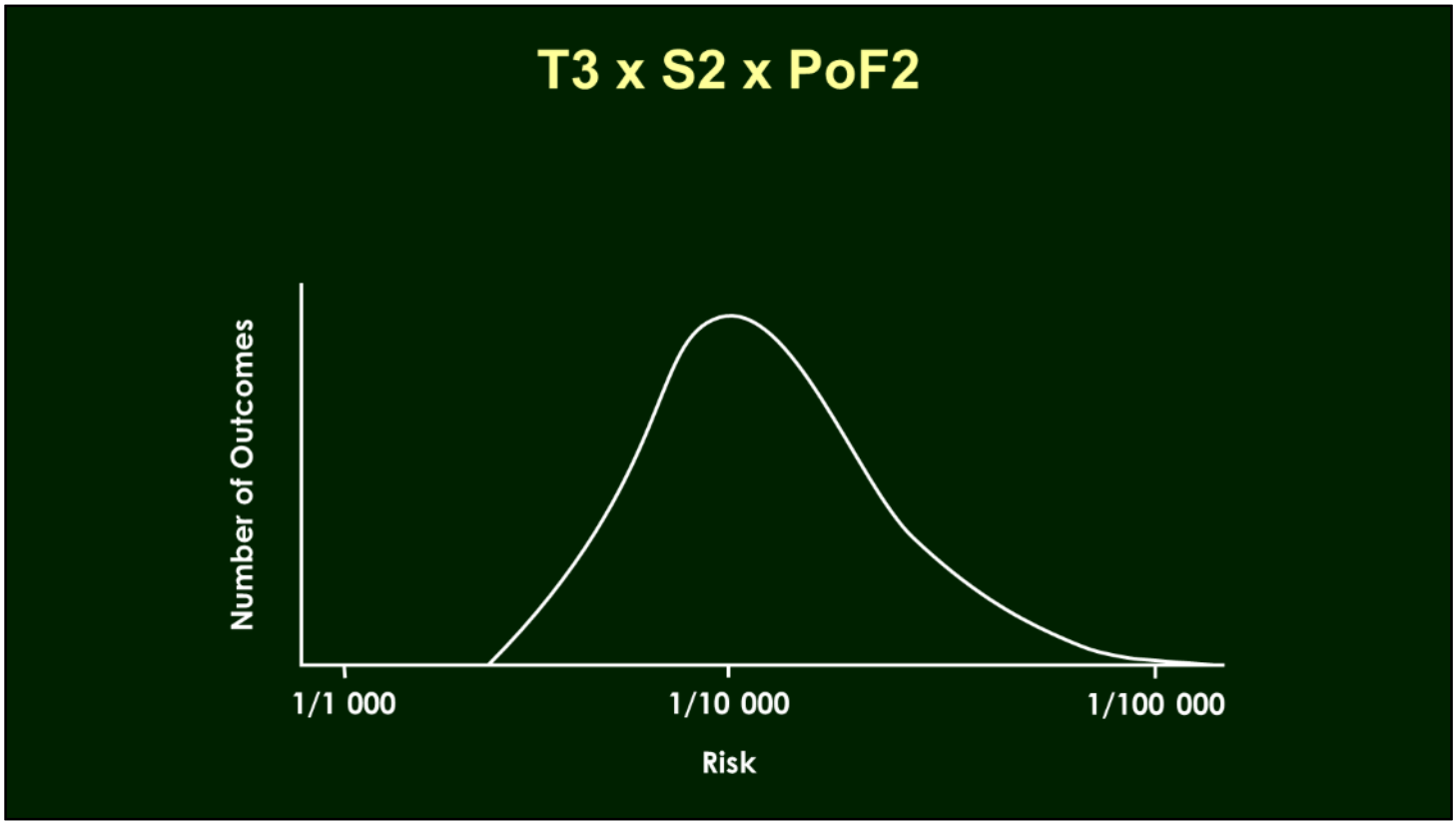
The Monte Carlo Simulation technique came from The Manhattan Project, where there was great uncertainty when Robert Oppenheimer and his team were putting together the first nuclear bomb.

The way they resolved this 'uncertainty problem' was to develop Monte Carlo Simulations to calculate the most likely outcome from a combination of inputs that had uncertainty.

Today, Monte Carlo Simulation is widely used by many professions whenever there is significant uncertainty with inputs, and there are a range of possible outcomes. As is the case in the calculation of risk.

Put simply, Monte Carlo Simulation enables better decision making where there is uncertainty.

QTRA v5 risk outputs are derived from Monte Carlo Simulations, and I'll show you an example of how they work.



This risk assessment is a graphic representation of the Monte Carlo Simulation for Target range 3, Size range 2, and Probability of Failure range 2. Note, the inputs are broad ranges and not exact numerical single point values because it's not reasonable or practicable to try be so precise.

What the Monte Carlo Simulation does is take random values from the three ranges, T3, S2, and PoF2 and plot the outcome. It does this for 10 000 combinations - called iterations.

It then produces a distribution curve like the one above.

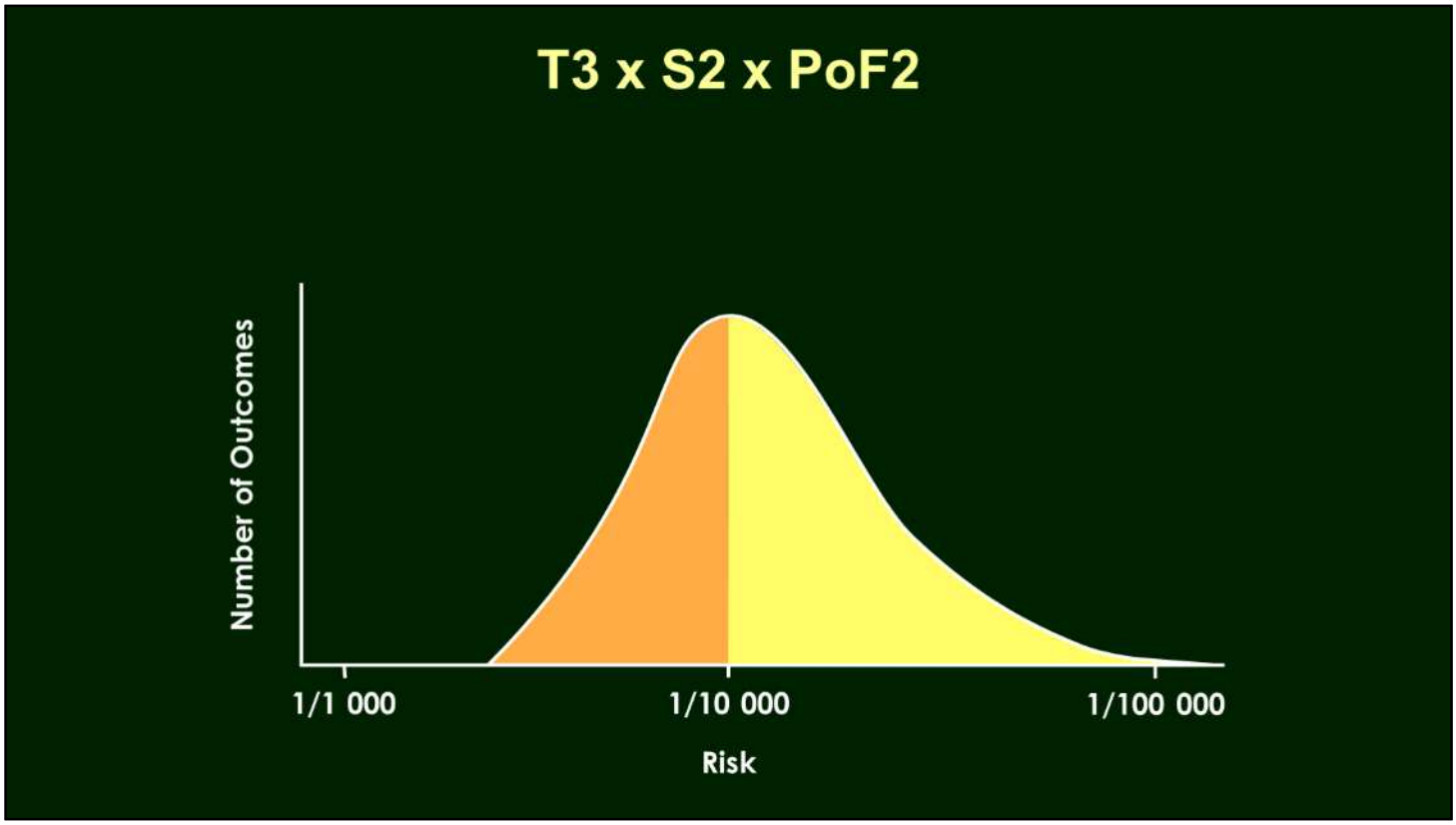
We don't go for the worst case outcome, what could happen, and be 'risk averse' by 'picking the nose' of the distribution.

Nor do we want to be 'reckless', and go for the best case outcome, by 'pointing to the tail' of the distribution.

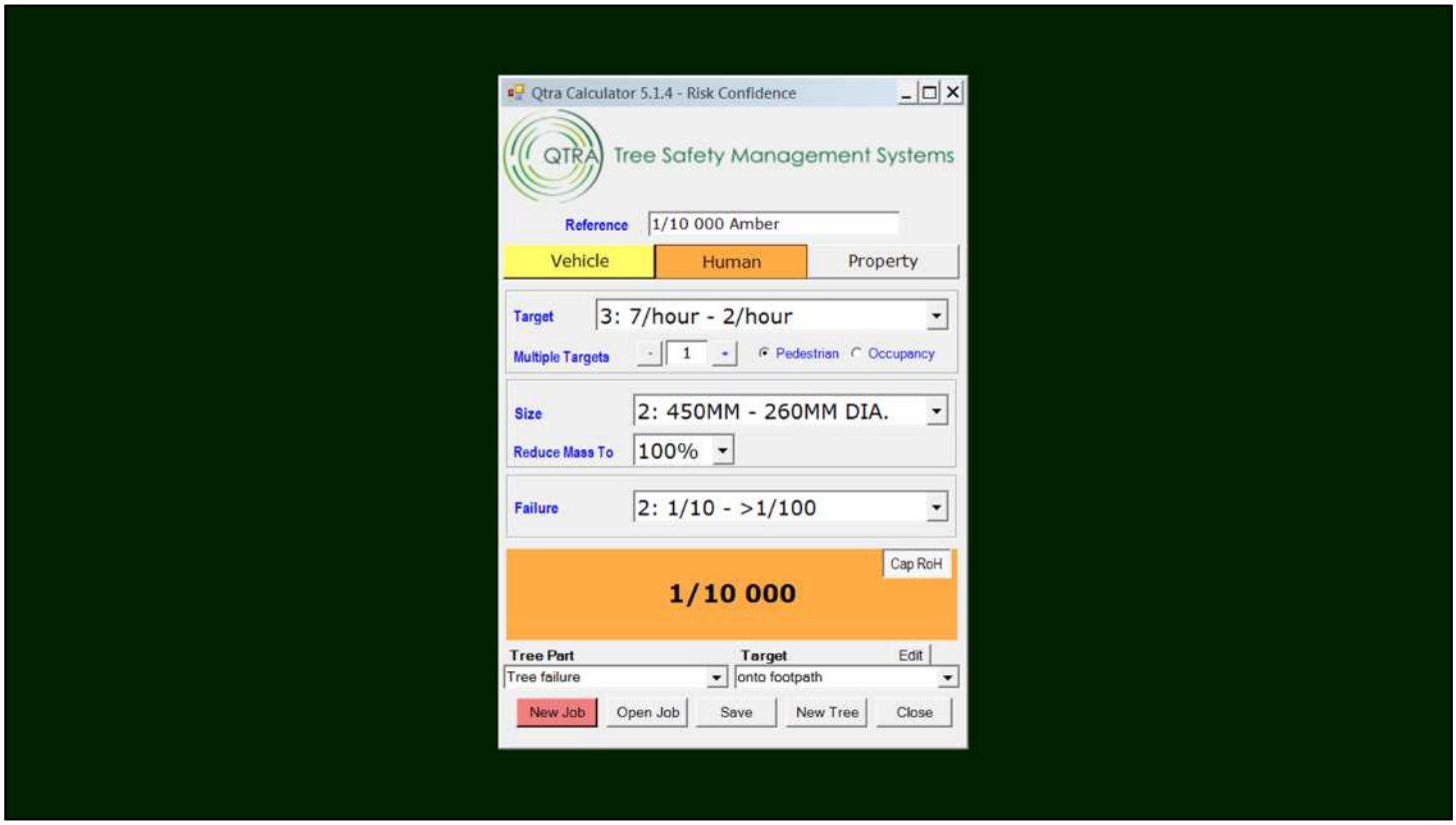
We go for the most likely outcome and be 'risk aware'.

With range inputs T3 x S2 x PoF2 the most likely outcome is 1/10 000.

We know from ToR that 1/10 000 is the highest Tolerable risk that can be imposed if it is ALARP.

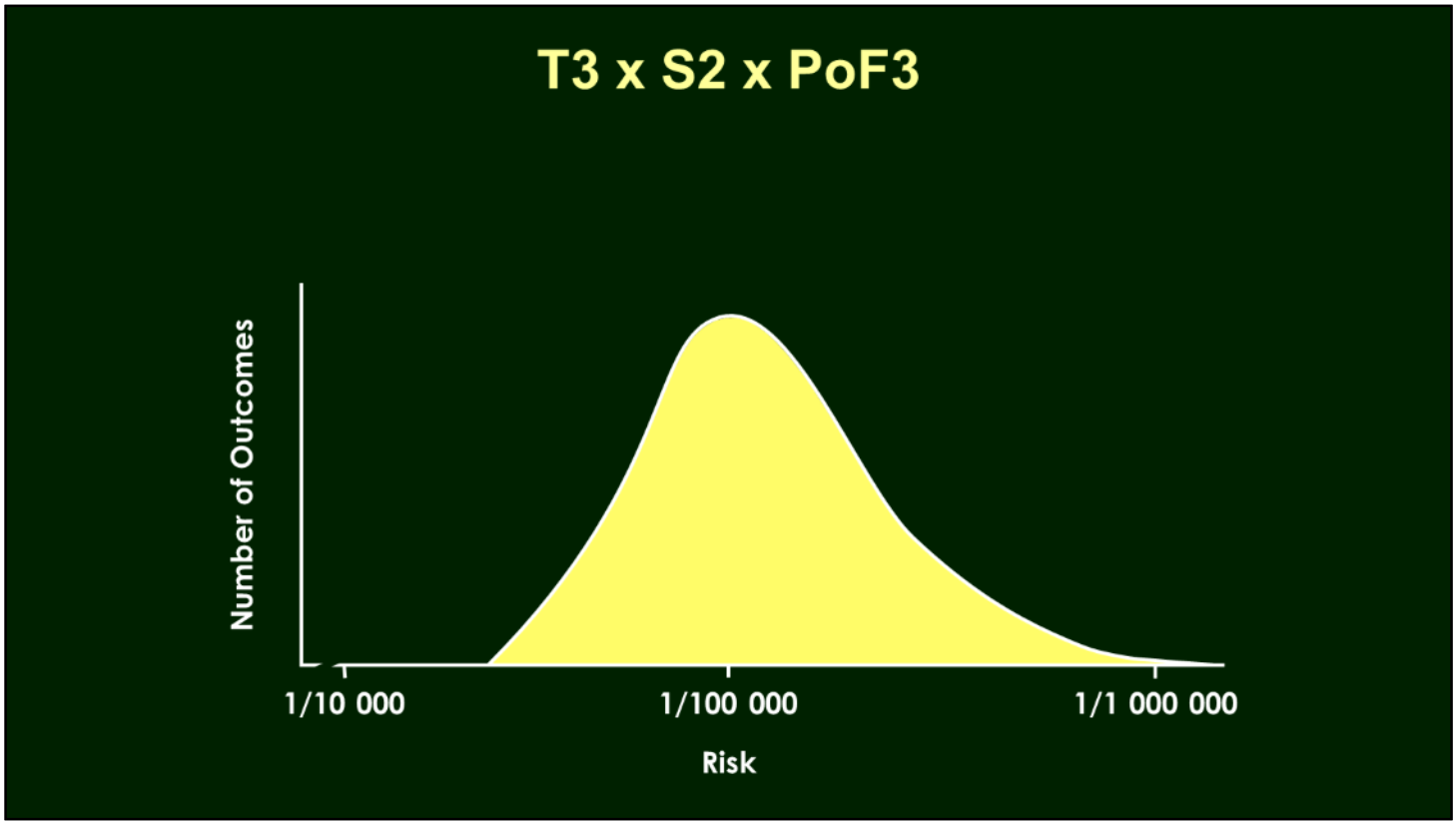


However, what the Monte Carlo Simulation shows is a QTRA risk of 1/10 000 is composed of 65% Yellow Tolerable and 35% Amber 'Unacceptable unless'. What this means is there's not enough Yellow in the QTRA risk output of 1/10 00 to colour it Yellow. There is too much Amber in the distribution, which means there's too much uncertainty and not enough confidence about the most likely outcome.



Therefore, the QTRA risk output for Target range 3, Size range 2, and Probability of Failure range 2 is coloured Amber, it's 'Unacceptable unless' in words, and 1/10 000 as a number.

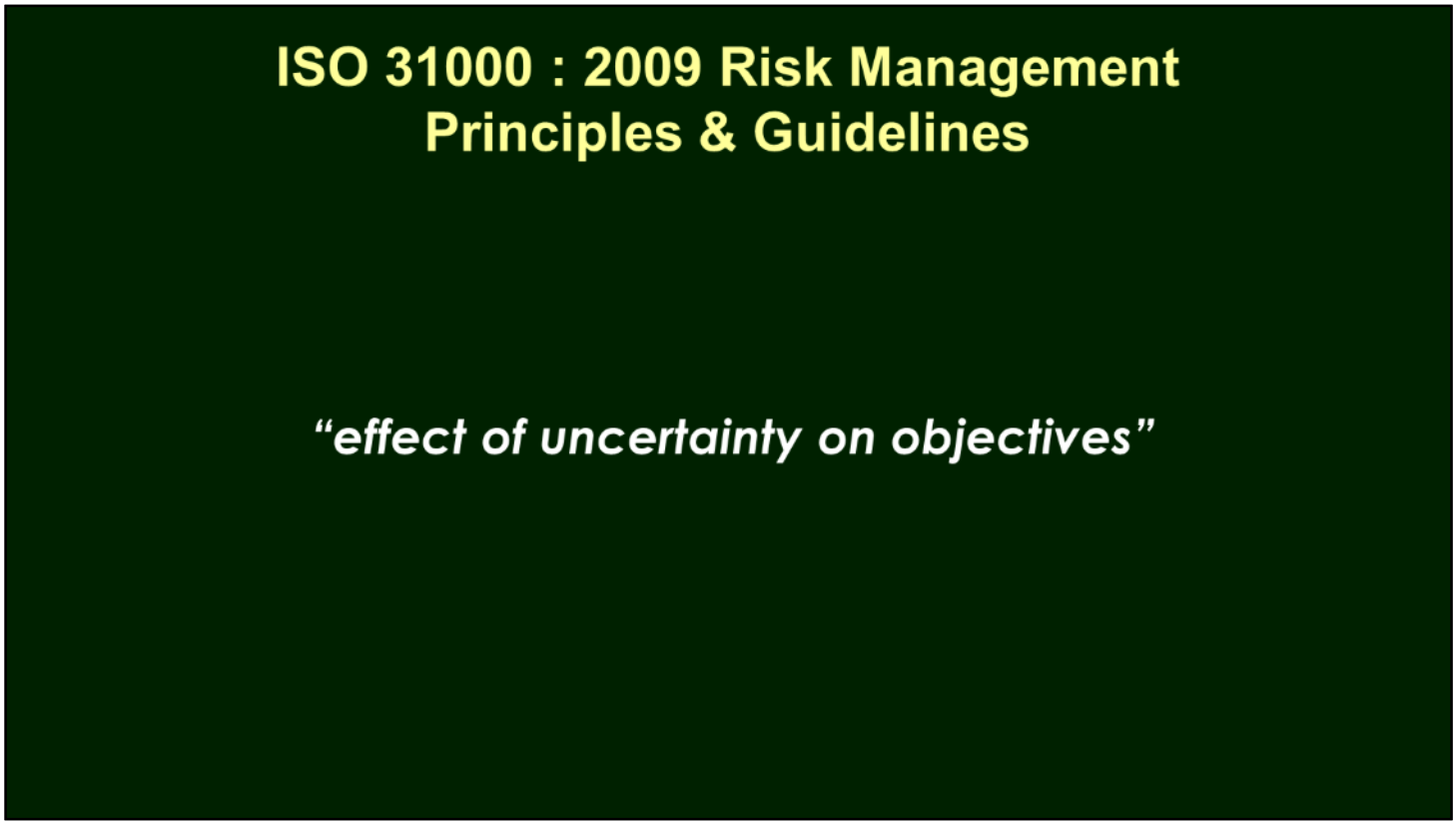
The closest a QTRA Yellow risk, from primary inputs, can get to the ToR risk tolerance threshold of 1/10 000, is 1/30 000.



Here's the Monte Carlo Simulation distribution for ranges T3 x T2 x PoF3.

With this most likely outcome we have high confidence in the colour of the distribution because it's nearly all Yellow (the tip of the tail is 3% Green). So this is a QTRA Yellow risk as a colour, Tolerable risk if ALARP in words, and the number is 1/100 000.

These powerful Monte Carlo Simulations are built into the QTRA calculators and do all the hard work for the risk assessor.



An alternative definition of risk to Likelihood x Consequences in ISO 31000 is,

"effect of uncertainty on objectives"

In v5, QTRA goes to great lengths to not be precise because with tree risk we're accounting for the inherent uncertainty in a such an assessment.

We're looking for the most likely outcome from the input of three broad ranges, and one of the great things about using Monte Carlo Simulations is it enables us to do that and account for 'uncertainty' in the inputs and outputs.

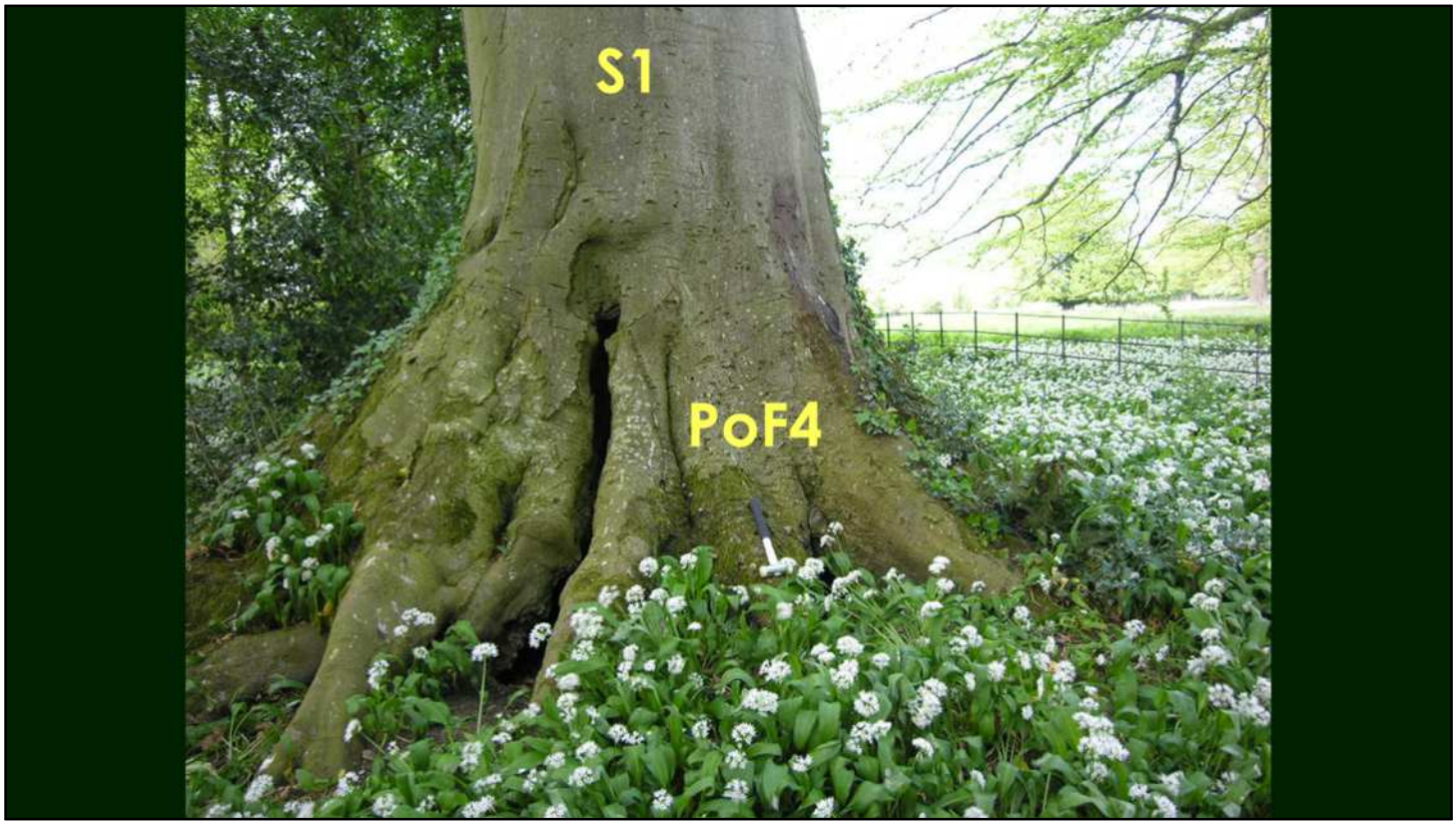
The risk assessor does not need to be familiar with complex maths in order to use QTRA. All they need to do is align the three inputs, within the broad ranges, and let the calculator do the rest.

.

I'm going to go through some case studies to demonstrate the benefits of using QTRA to the risk assessor and the risk owner/manager.

Here's a mature European Beech tree in significant decline.

The risk is for whole tree failure, and the 'weather-affected' Target is the path in the foreground of this woodland.



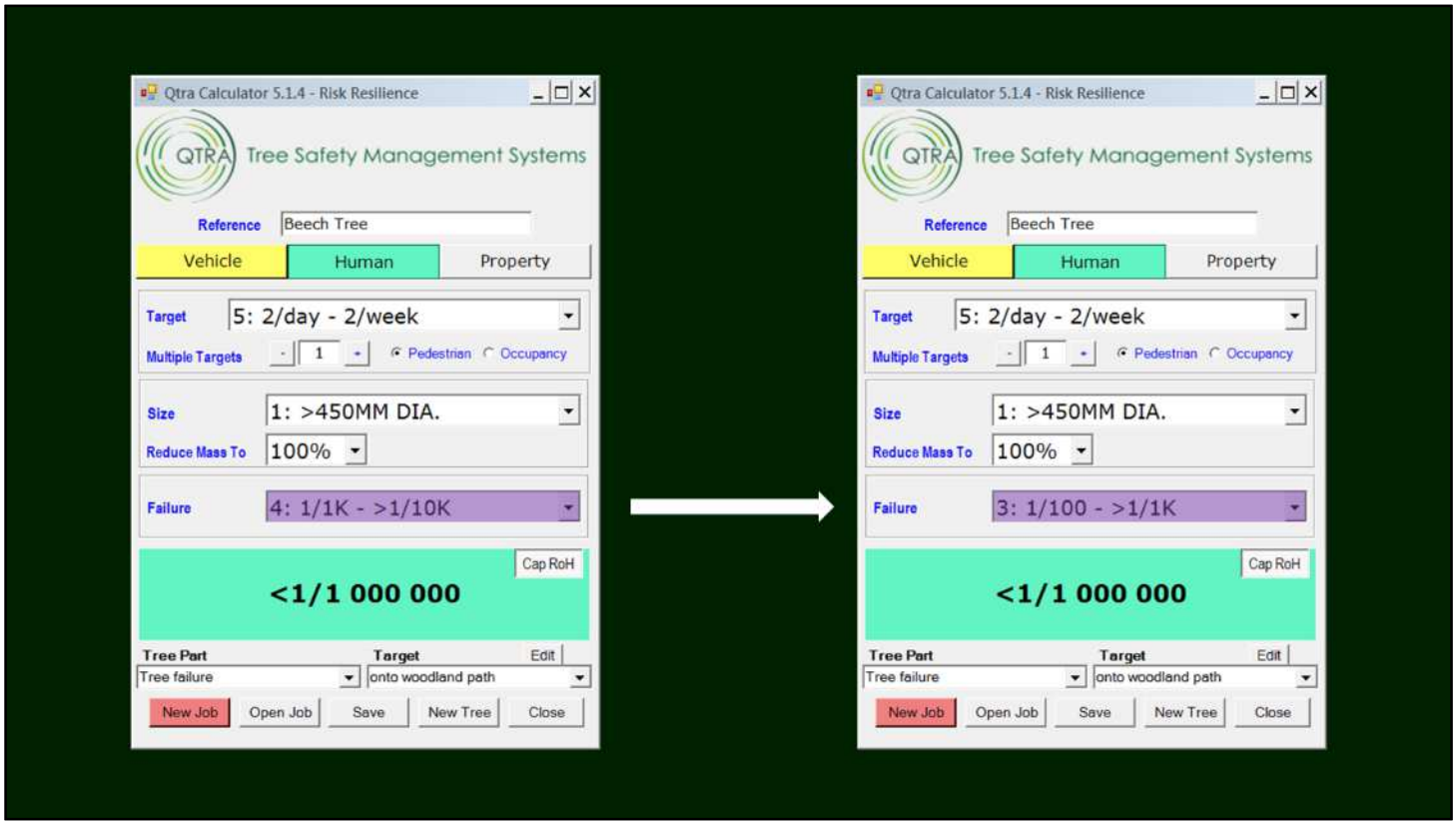
The tree has;

An open cavity.

Simultaneous white rot from *Ganoderma* sp.

Soft rot from *Kretzschmaria deusta*.

Phloem necrosis – tarry spots.



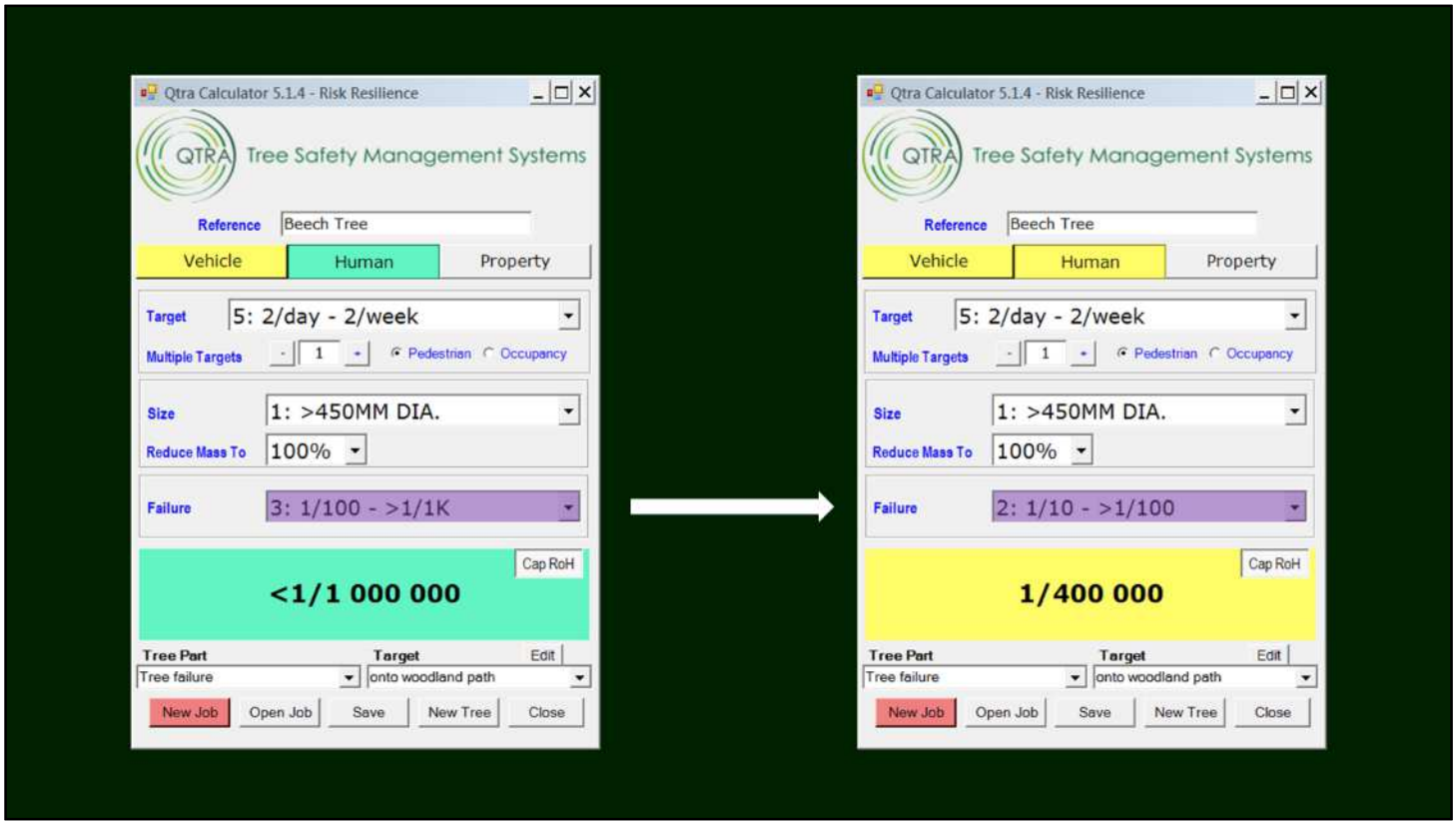
Here, the risk is Green as a colour, Broadly Acceptable in words, and less than 1/1 000 000 as a number.

My PoF range is 4, which is the range furthest from each benchmark, and it has the highest level of uncertainty.

I'm going to test the resilience of this risk assessment.

What I'm going to do is increase the PoF range by a factor of 10 from Range 4 to Range 3.

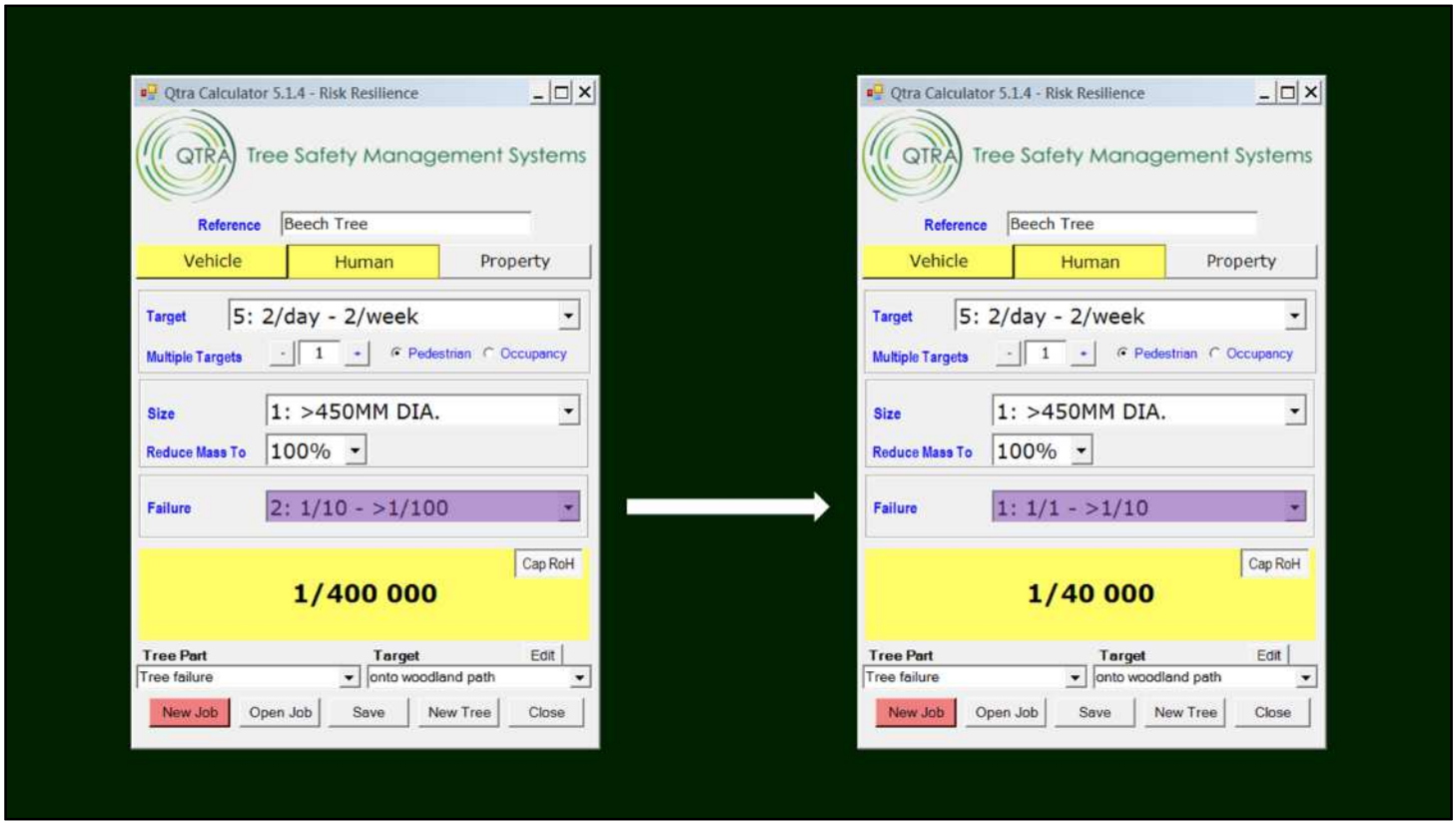
The risk is still Green, 1/1M, and Broad Acceptable, even if I'm out by a factor of 10.



I'm going to increase the PoF range by another factor of 10.

The risk is now Yellow as a colour, Tolerable if ALARP in words, and 1/400 000 as a number.

The risk is Tolerable even if I'm out by a factor of 100.



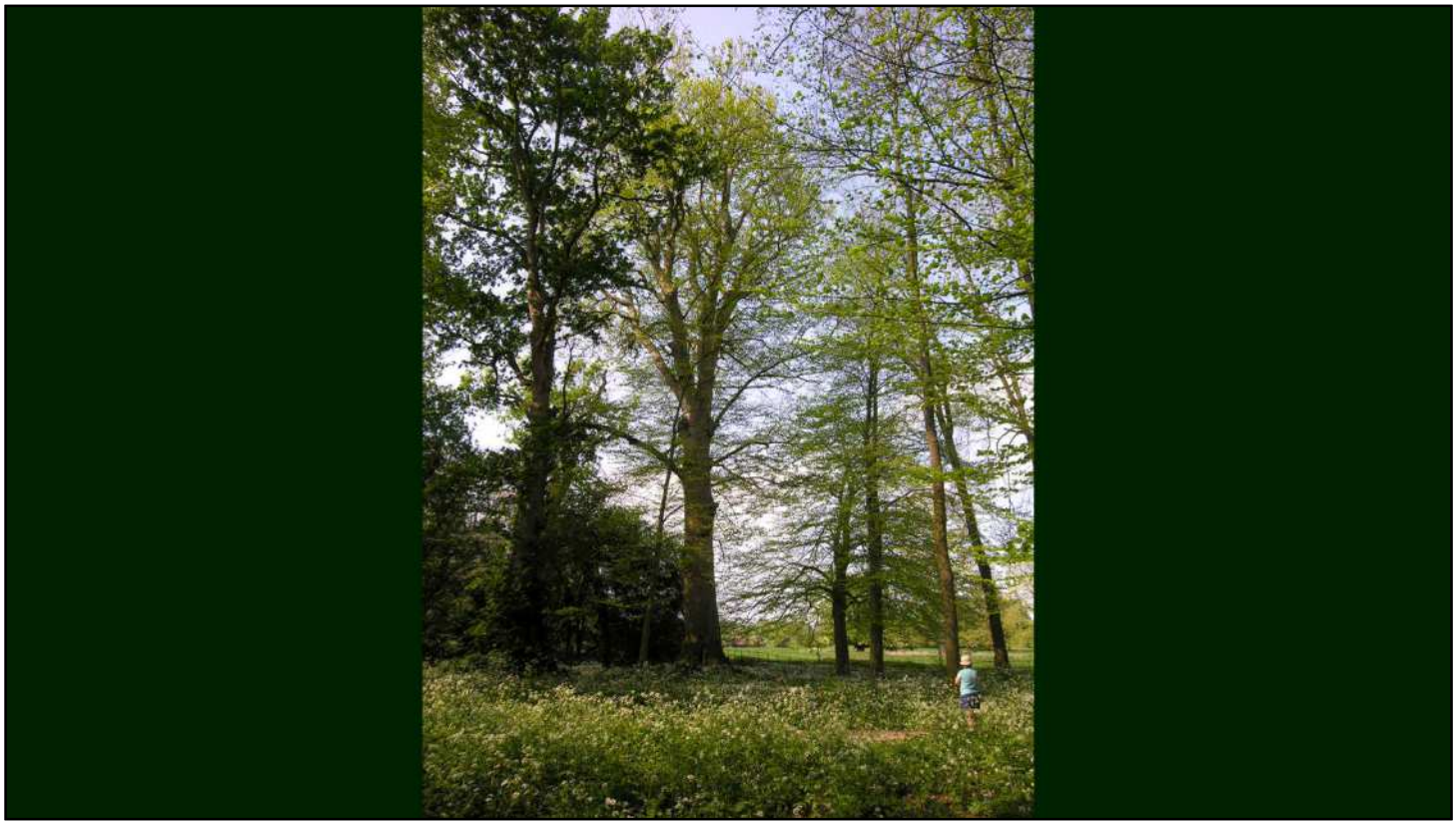
I'm going to increase the PoF range by another factor of 10.

The risk is now still Yellow as a colour, Tolerable in words, and 1/40 000 as a number.

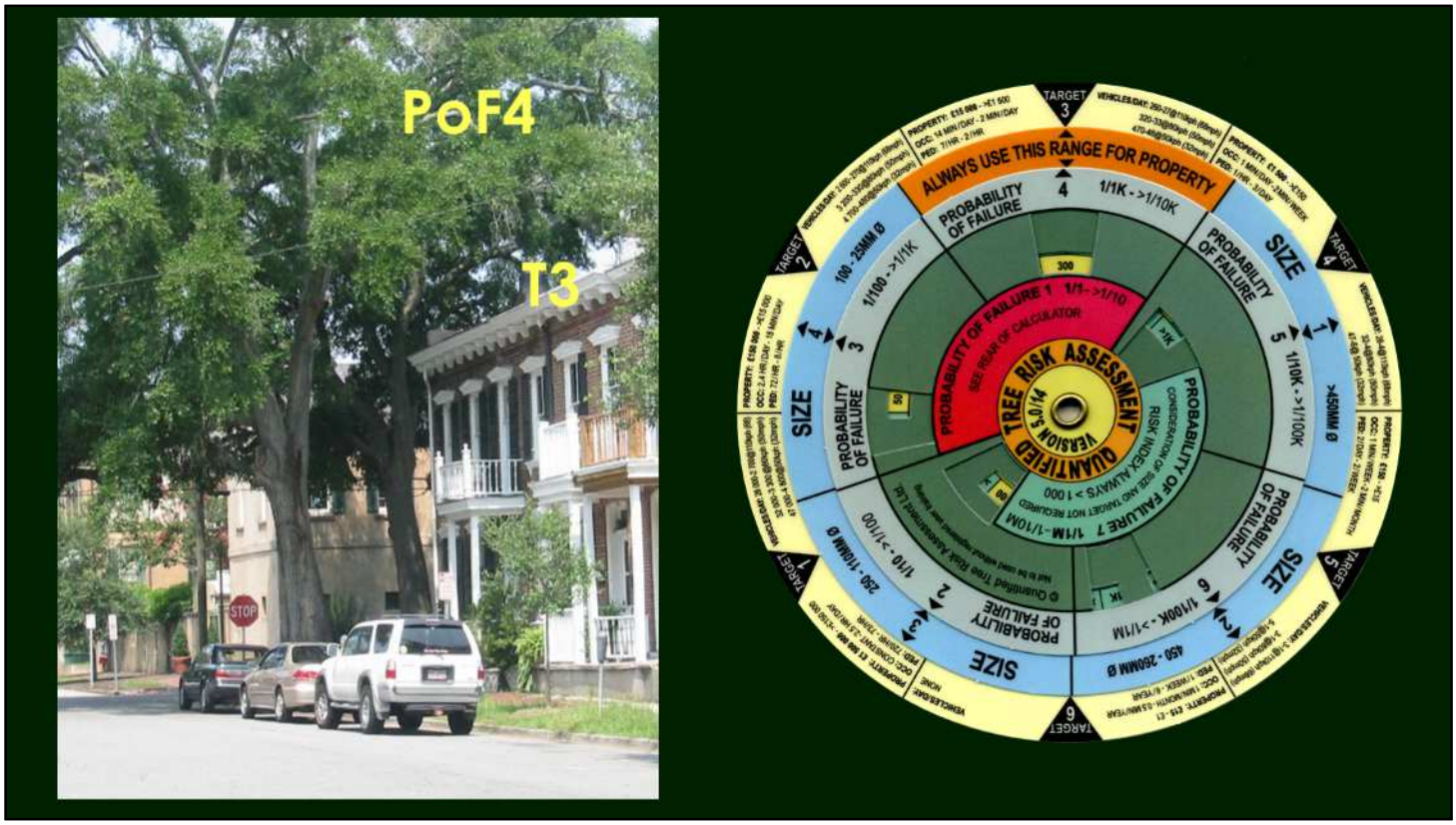
The risk is Tolerable even if I'm out with my PoF by a factor of 1 000.

Therefore, my risk assessment has a lot of resilience to it.

Both the risk assessor and risk owner/manager can have a high level of confidence in this risk assessment.



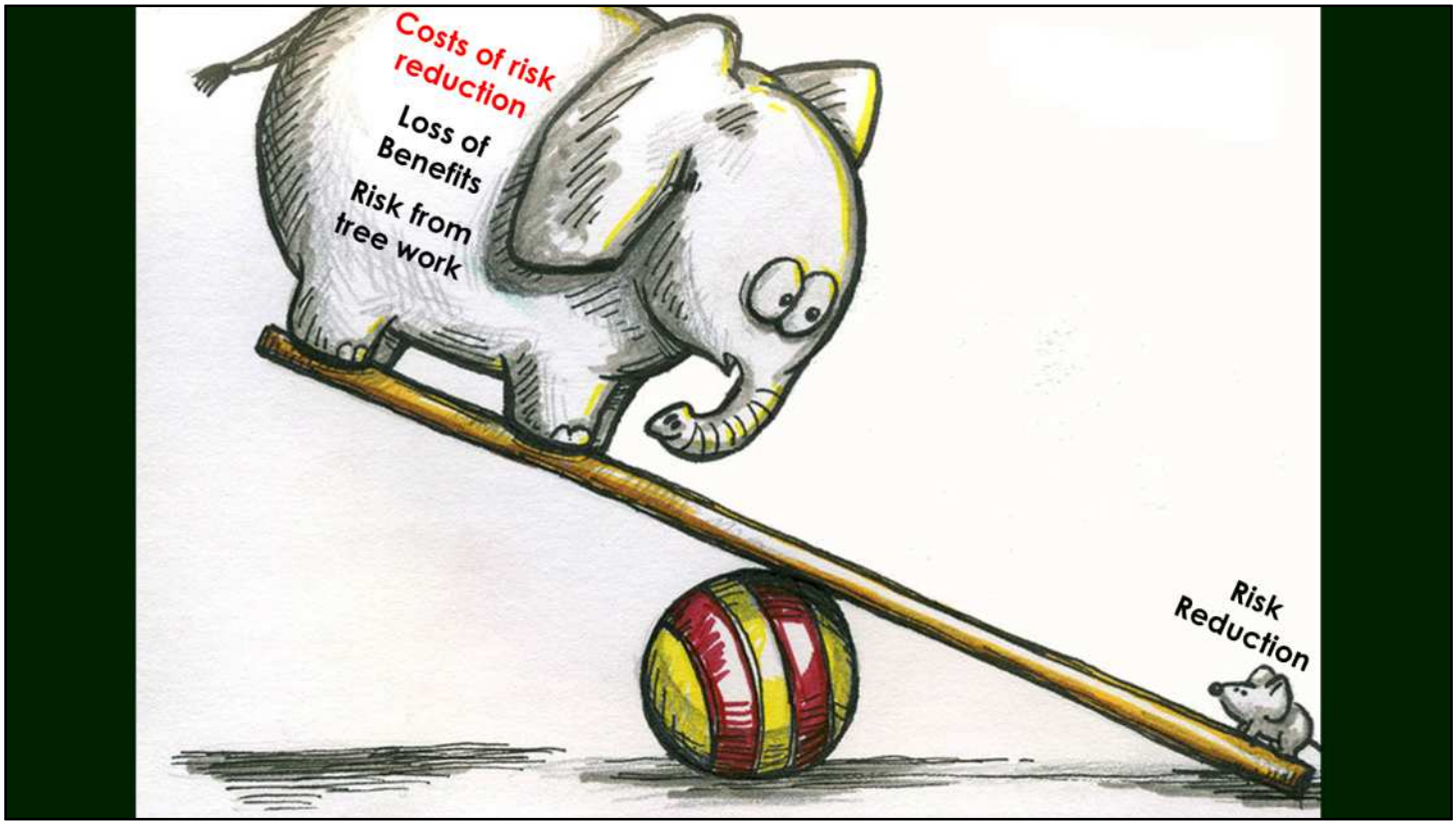
The risk owner/manager can leave this large tree alone to naturally decline and provide valuable habitat, and demonstrate the risk is Green as a colour, Broadly Acceptable in words, and less than 1/1 000 000 as a number.



The next case study shows how to estimate whether a Yellow tolerable risk is ALARP.

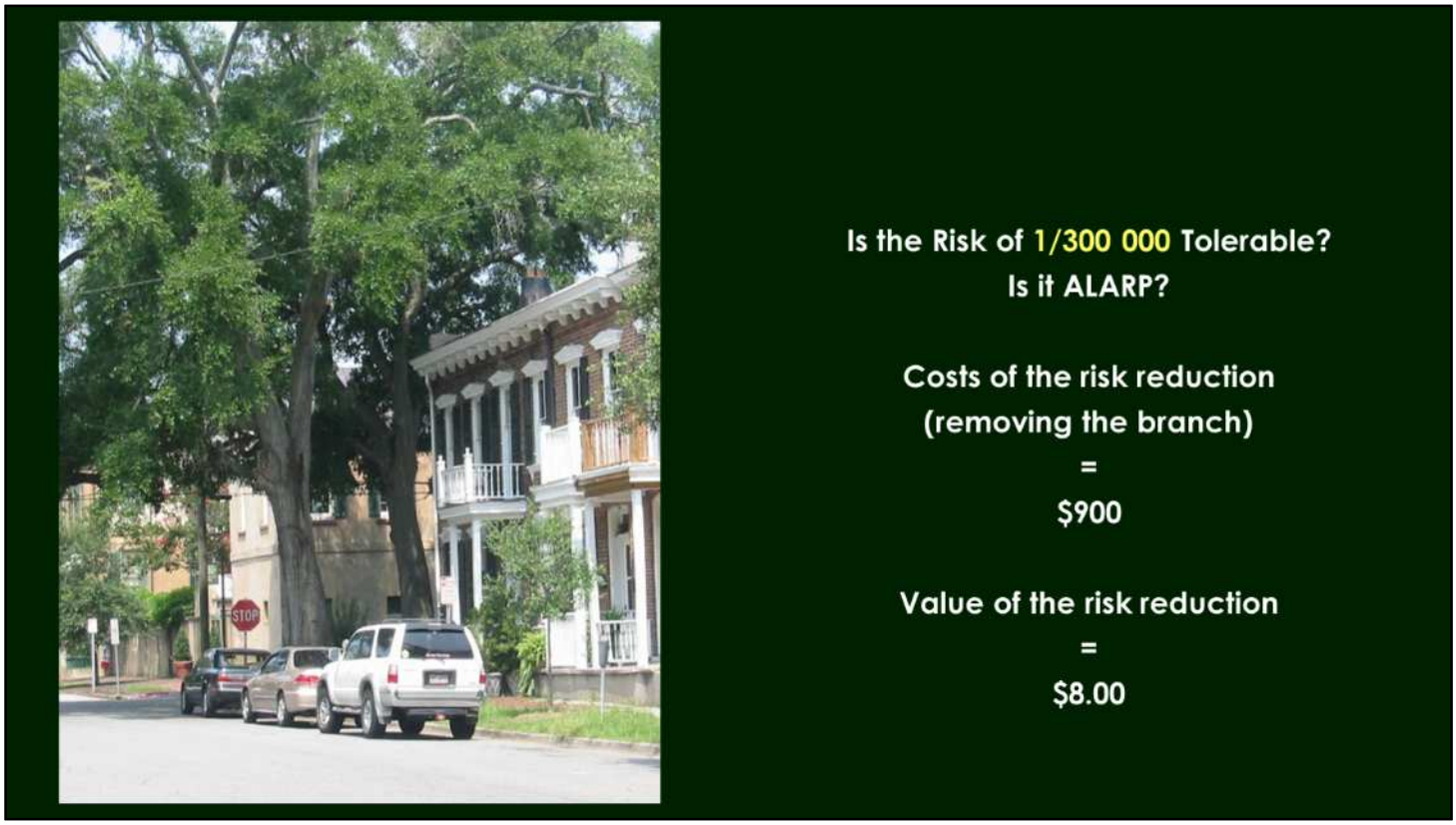
A branch failing from this tree onto the roof of the house is estimated to cost $15 000 (US) dollars worth of damage.

The risk is Yellow as a colour, which means it's a Tolerable Risk if ALARP, and is 1/300 000 (300 risk index) as a number.



It's time to acknowledge the elephant in the room and measure part of its weight.

The part of the elephant we're going to measure are the costs of the risk reduction.



What this shows is that spending $900 on tree work buys $8.00* worth of risk reduction.

The risk owner/manager is able to demonstrate the risk is Tolerable and that to mitigate or reduce the risk any further, is 'disproportionate'. The risk is therefore Yellow Tolerable and ALARP.

Most Yellow Tolerable risks will usually be ALARP unless they are in the upper Yellow region of ToR, the tree is declining, and the benefits it provides are therefore diminishing.

…..

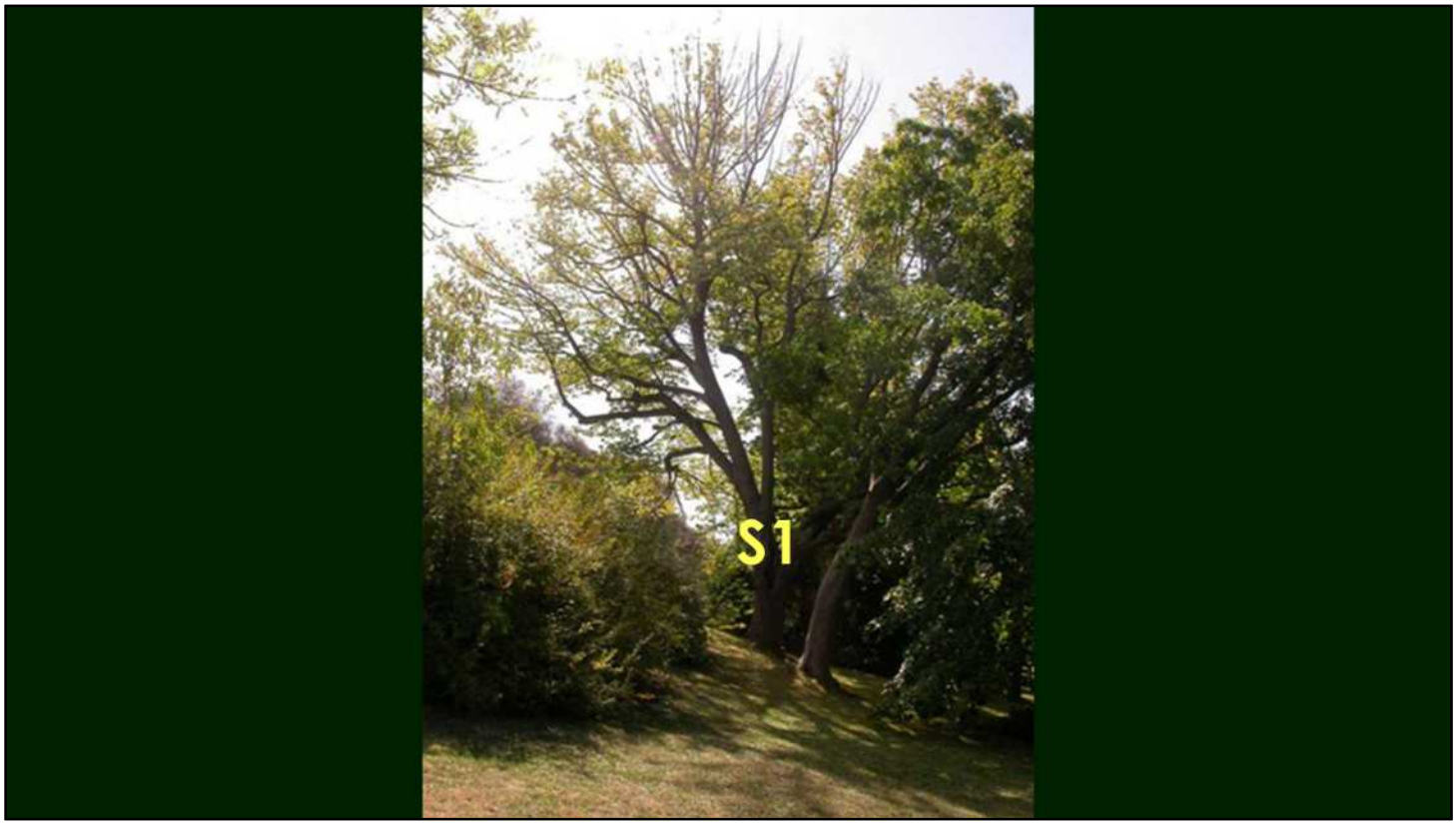
* $2 400 000 (USA Value of Statistical Life) x 1/300 000 = $8.00

The last case study looks at risk resilience, confidence, Probability of Failure, risk review periods, and ALARP.

From Hobart Botanical Gardens, Tasmania, Australia during QTRA training in 2014.

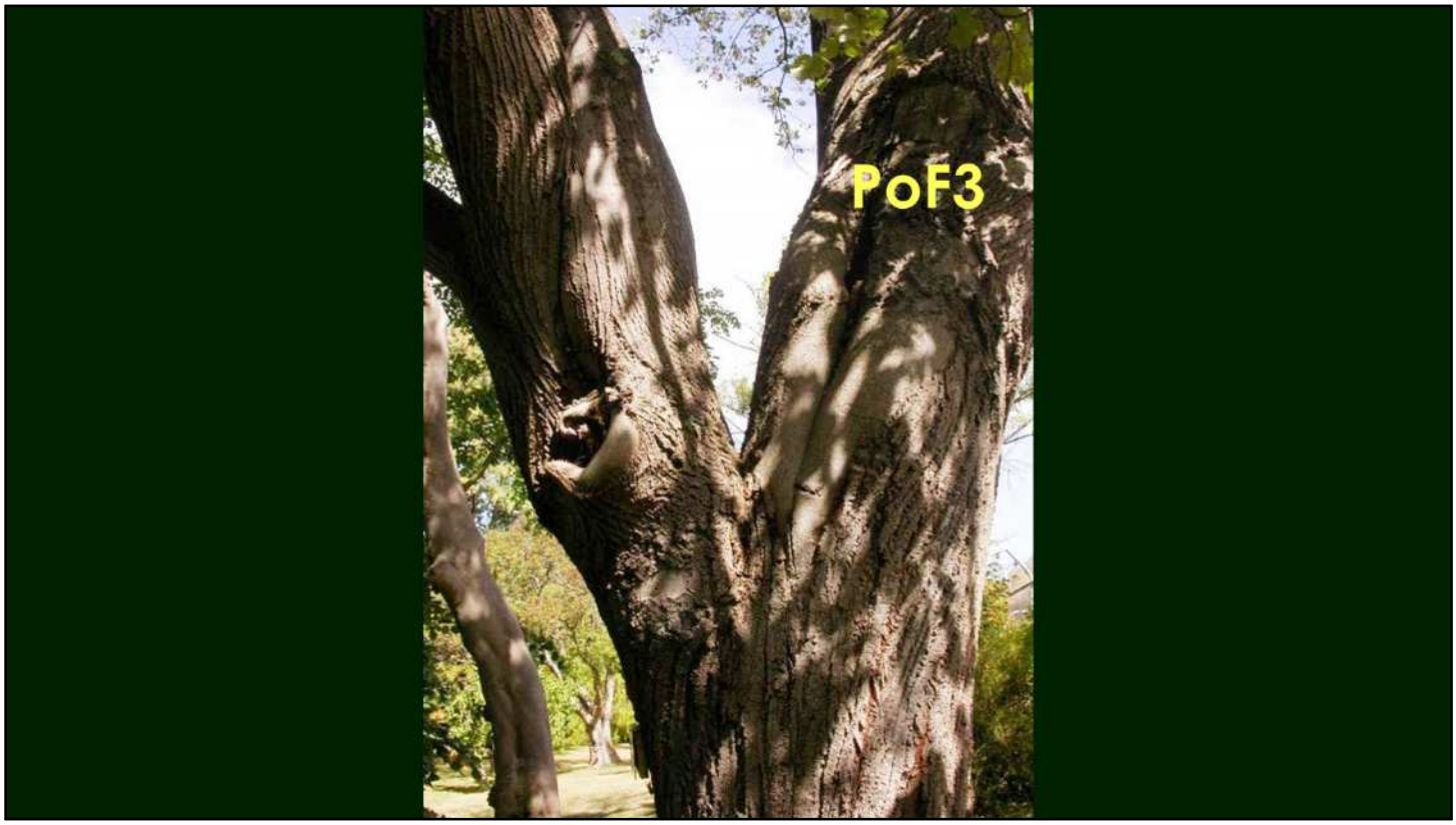
Tilia tomentosa – Silver Lime

Target range first - T3.

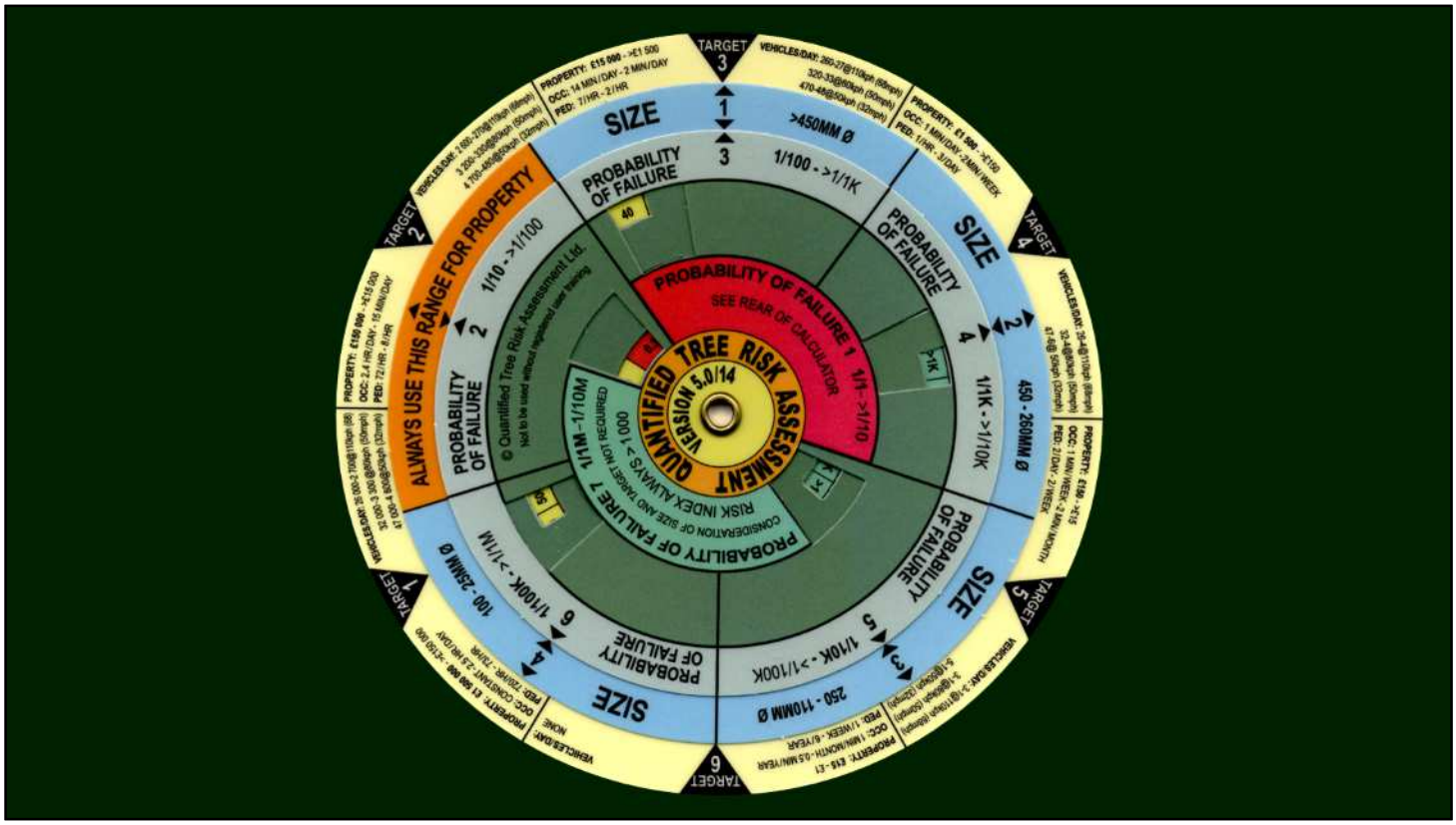


Left-hand stem overhanging Target.

Tree in considerable decline.



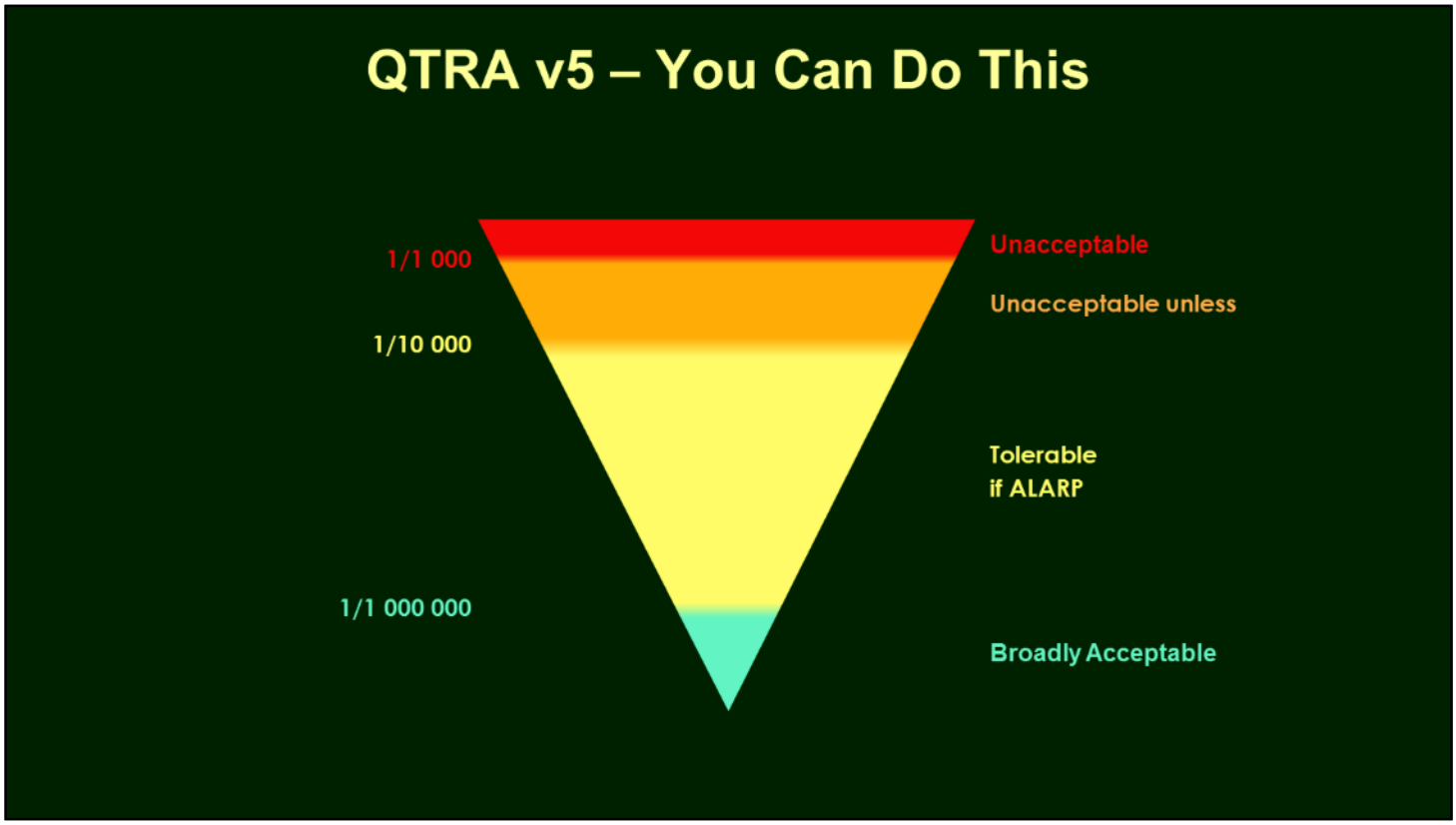
Likely failure point assessed – Right hand stem over road.



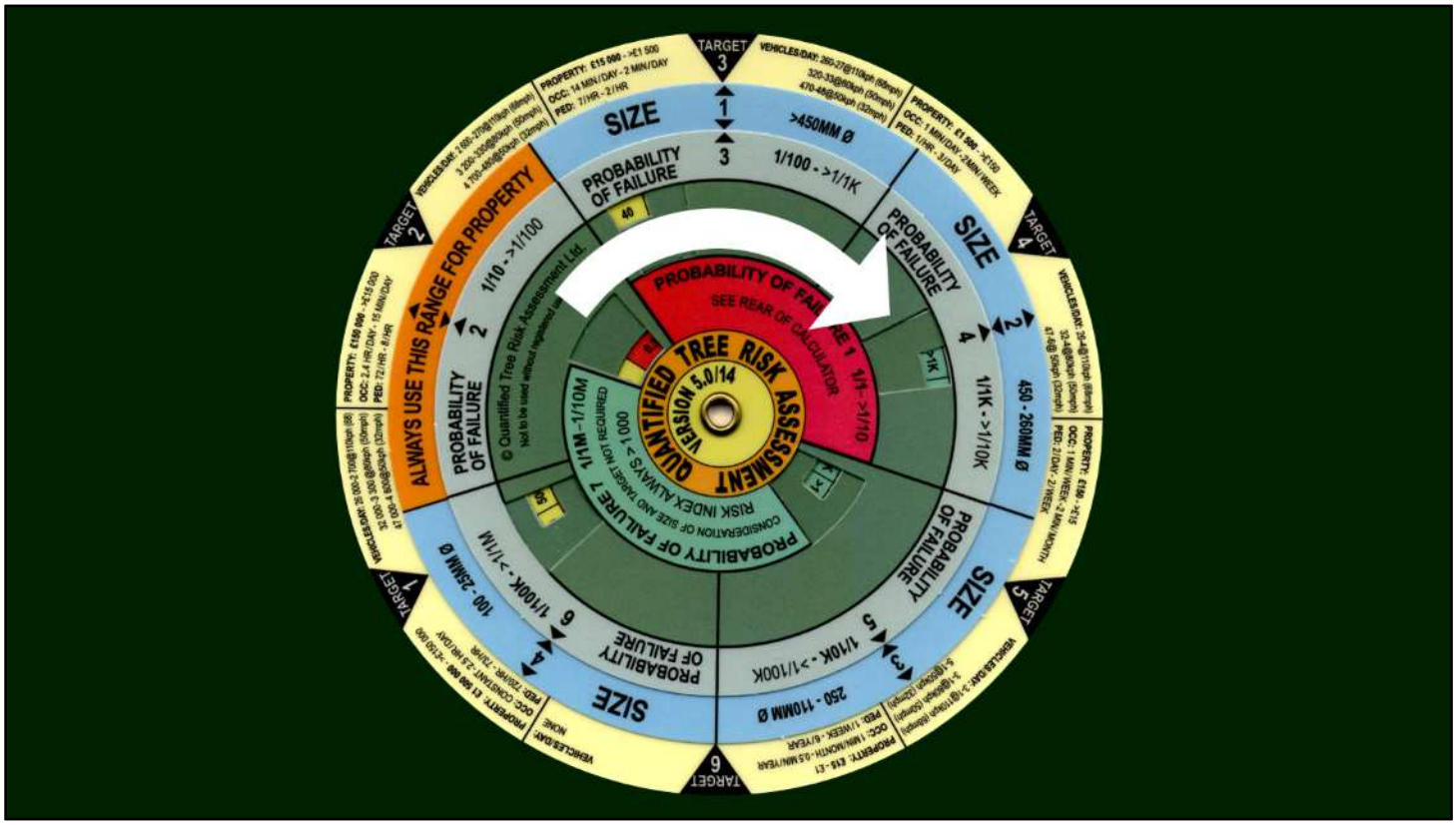
A Yellow Tolerable risk at 1/40 000 (Risk index 40) is calculated.

However, there's a number of issues with this risk assessment that need consideration.

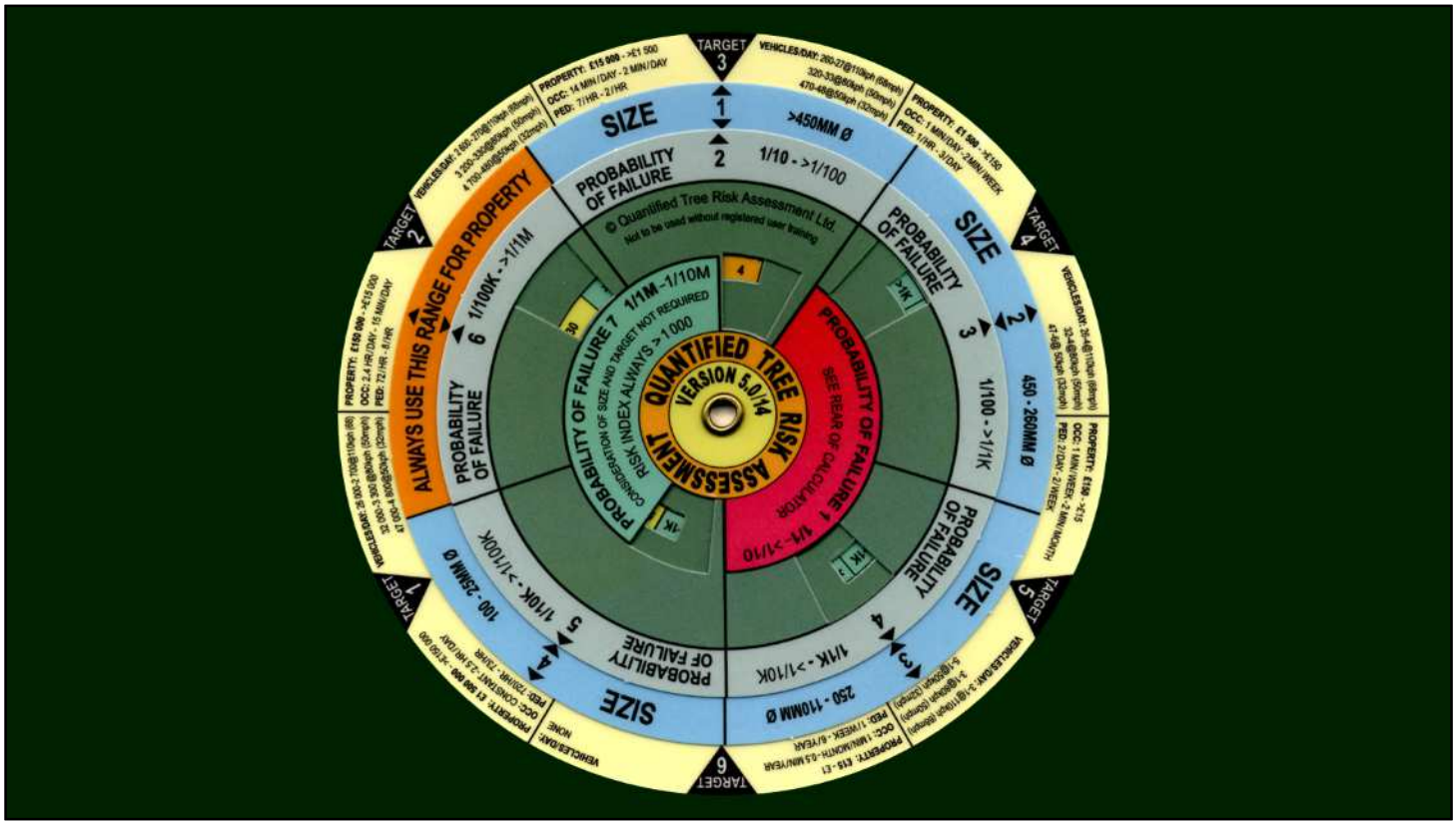
Firstly, we're in the upper part of the Yellow Tolerable region.



We're approaching the fattest part of the ToR triangle which is coloured Yellow, so we should be paying more attention to risks that are located up here.



Let's test the resilience of this risk assessment by jumping the PoF one range higher, by a factor of 10, from Range 3 to Range 2.



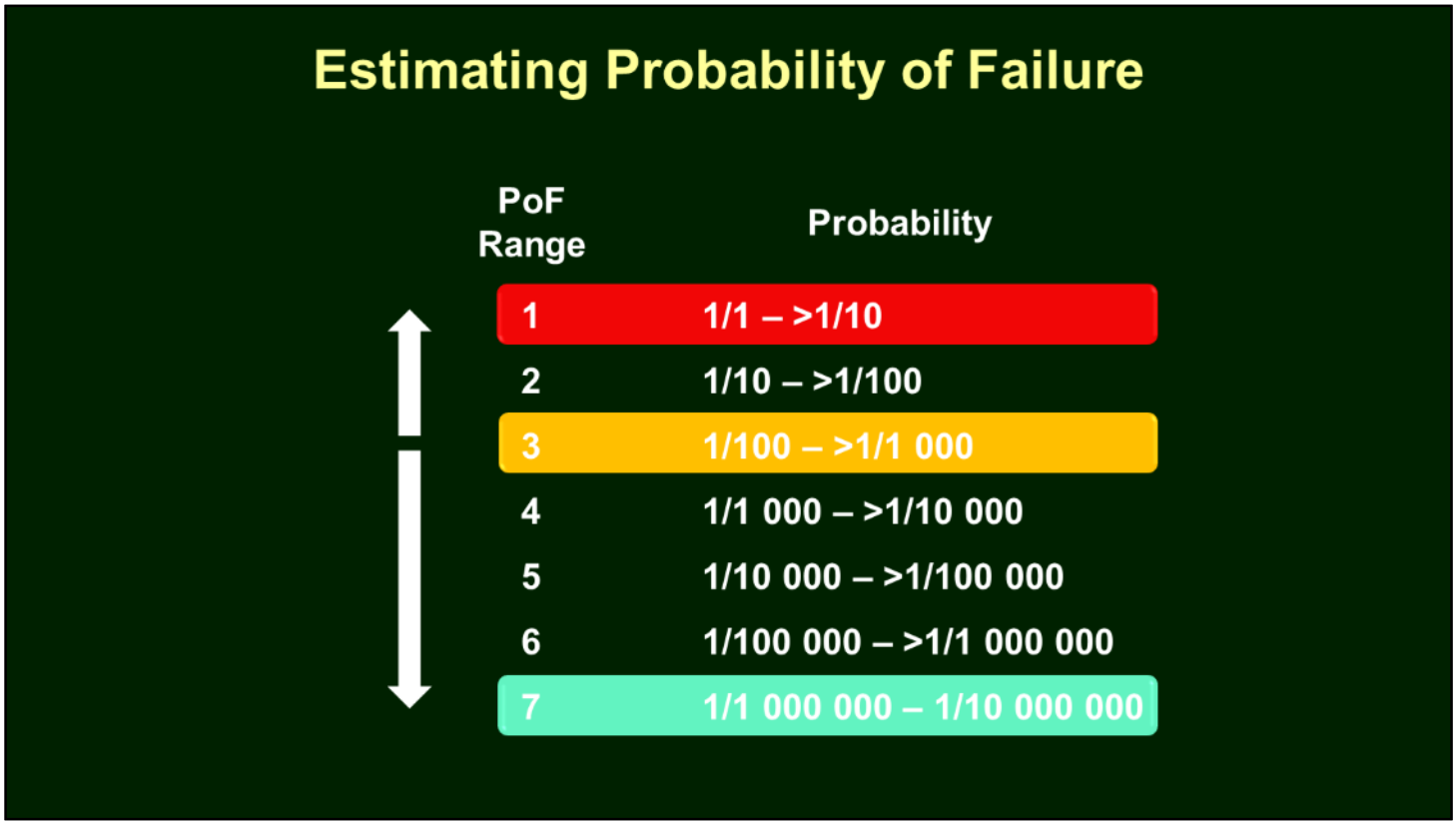
When we jump the PoF one range higher, the risk goes from Yellow to Amber, which is an 'Unacceptable unless' risk.

There is little resilience in this risk assessment.

The risk output is close to a risk tolerance threshold and this is telling us we need to have high confidence and low uncertainty in our inputs. This is the guidance whenever there is low 'risk resilience'.

Another important issue is, though the risk could be Yellow Tolerable, where is the risk heading during the risk review period?

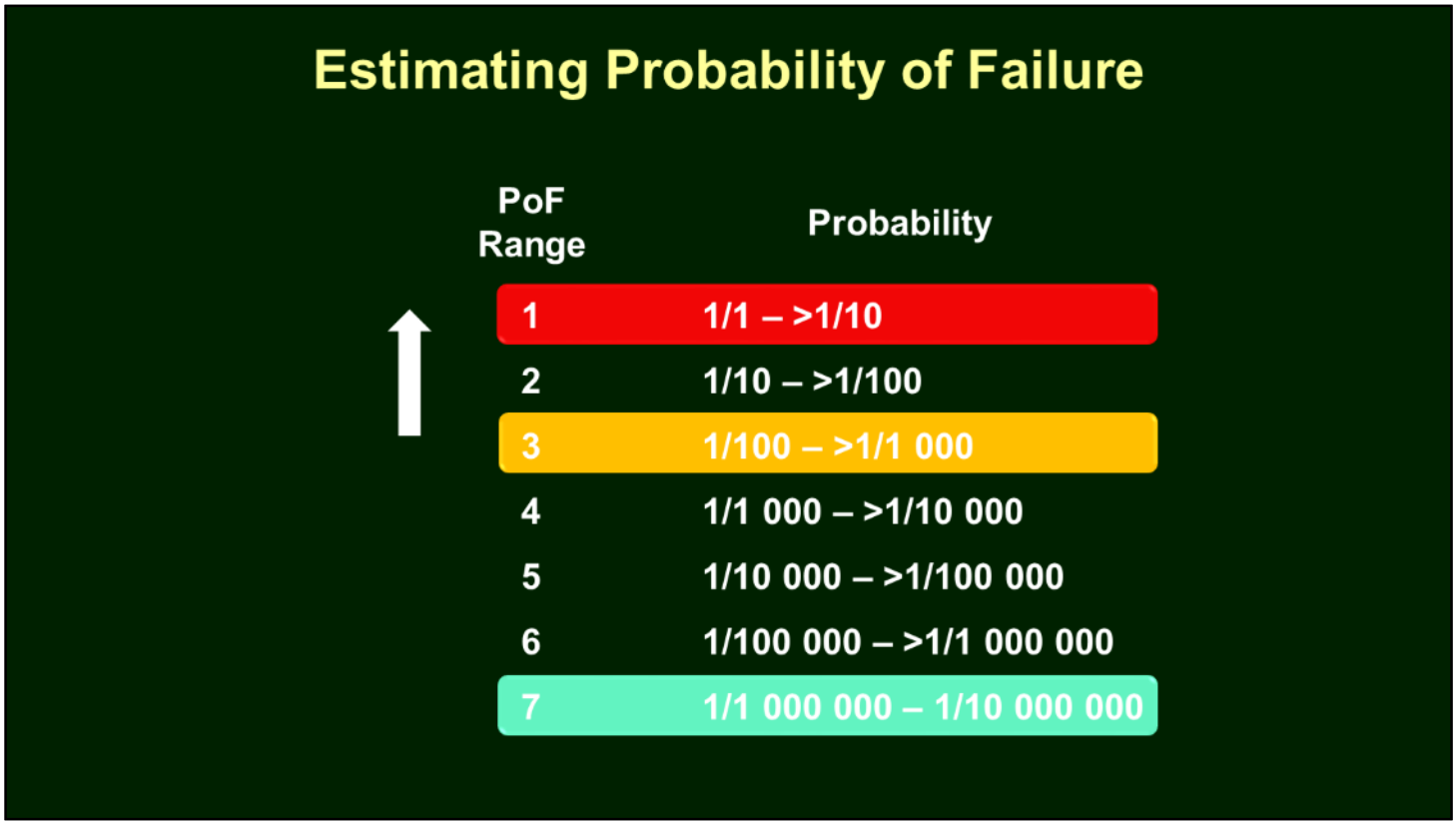
The question to ask is which way is the PoF of this tree heading?



Is the tree recovering and the Probability of Failure heading to Benchmark Green 7?

Or is the tree declining and heading to Benchmark Red 1?

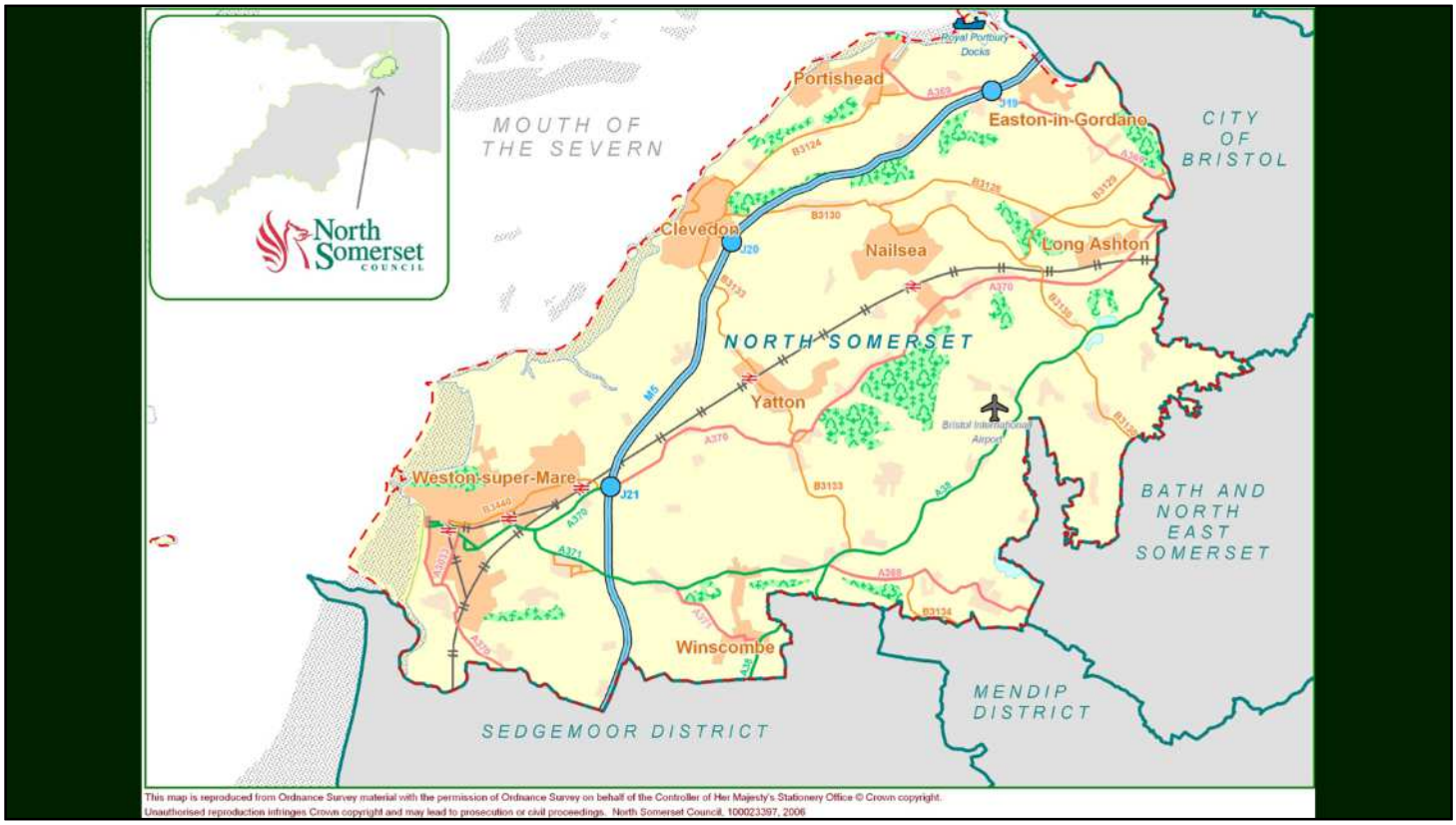
The tree is clearly in advanced decline, has slid a long way down its 'mortality spiral', and the benefits it provides will be diminishing.



It's heading to PoF Benchmark Red 1, and it likely to go from a Yellow Tolerable risk to an Amber Unacceptable risk within the risk review period.

Under such circumstances the risk assessor would draw the attention of the risk owner/manager to this and propose that if they have the budget they might consider mitigating this risk even though it is currently Yellow.

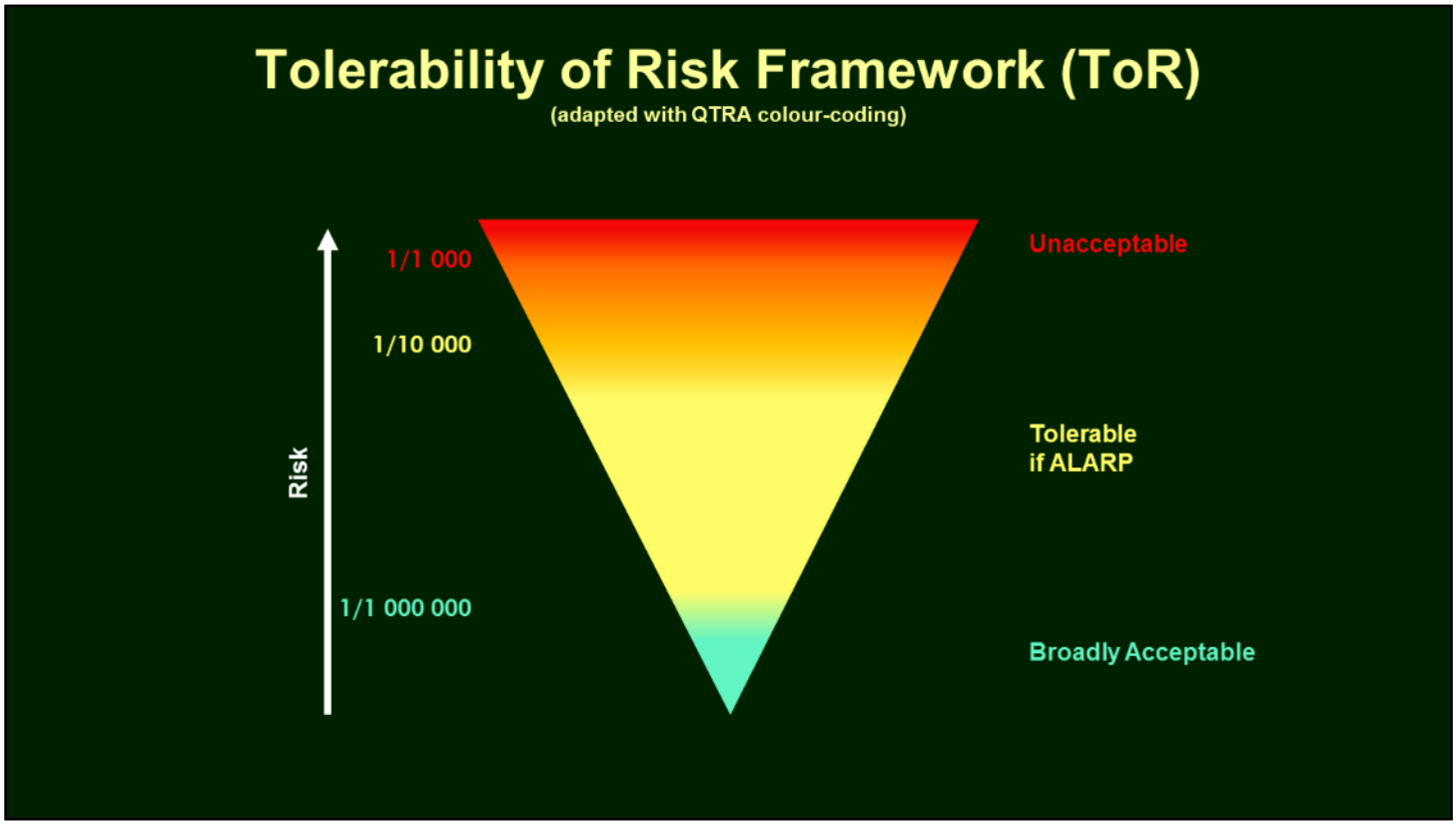
The owner/manager would, of course, spend their budget first on any Red or Amber trees. Prioritising the tree work by colour and then by number.



Let's try walking in the shoes of the risk owner/manager who determines the level of risk they can reasonably impose on members of the public from their trees. Along with all the other risks they have to manage.

An ever increasing number of municipalities and land owners are adopting the QTRA approach to risk assessment and risk management because ToR, along with the words and numbers QTRA uses, is a language their risk managers and insurers completely understand. It's the way other professionals deal with risk.

North Somerset District Council (NSC) is a municipality in the UK which is responsible for an estimated 300 000 trees. They were an early adopter of the QTRA approach to tree risk assessment and risk management.



In simple terms, their arboriculturists and risk managers produced a tree risk management policy that effectively says:

Trees have all these benefits and we are going to manage the risk we impose from our trees to ToR risk tolerance thresholds.

Their elected members then voted for the policy.

Having adopted these principles, NSC have found the QTRA approach to be so cost-effective, it's annual spend on tree risk assessment and the resulting tree risk mitigation has halved from £200 000 to £100 000.

NSC are currently reviewing their Tree Risk Policy with the aim of producing it in a simpler format, but with the same ToR risk tolerance thresholds. Their current Tree Risk Management plan can be downloaded here.

http://tinyurl.com/onfbjwl

Or search "North Somerset Council Tree Risk Management"

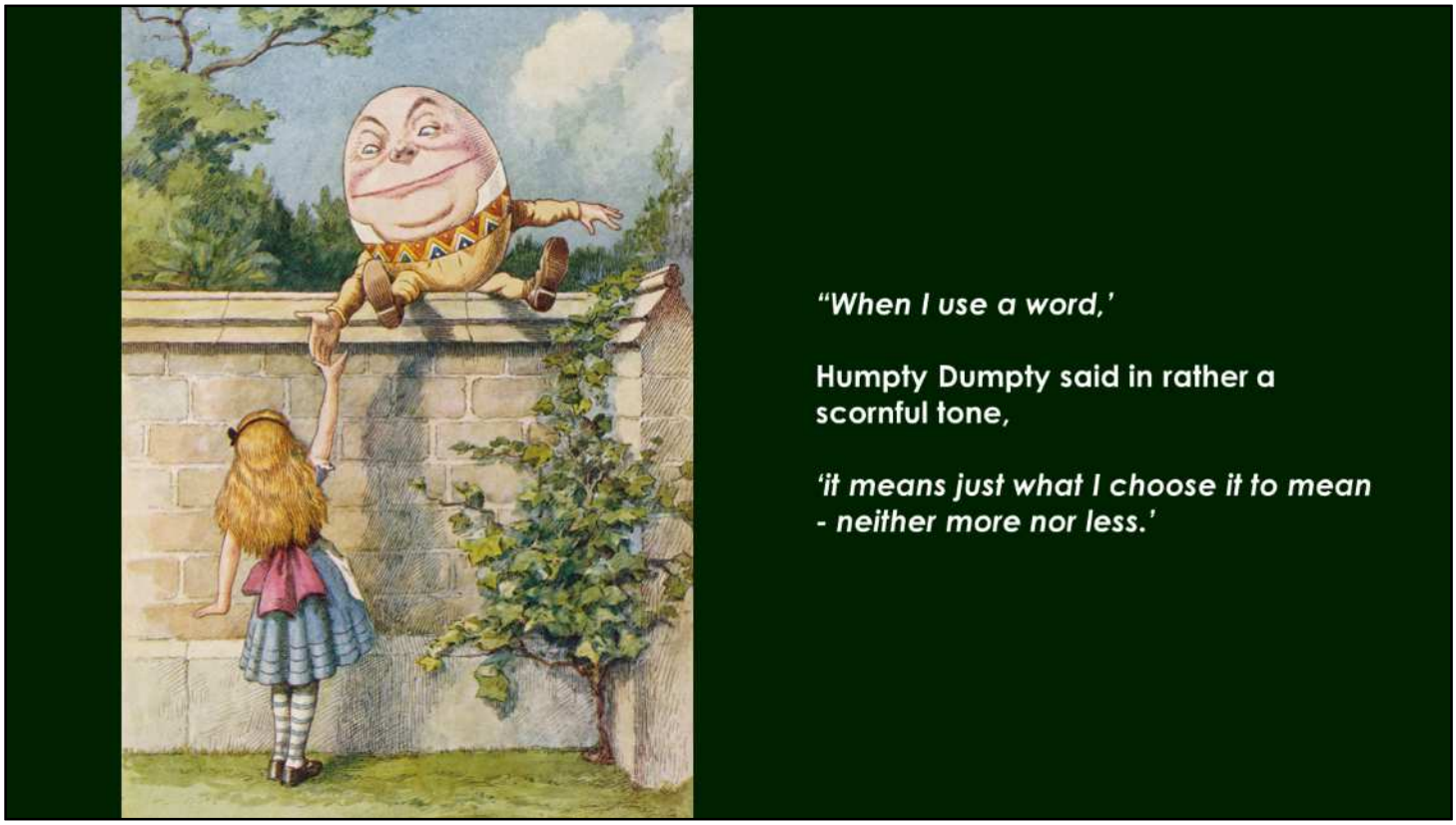
Adopting ToR risk tolerance thresholds means that not only are NSC able to allocate limited resources to where they are most cost-effective. They are also in a robust position to defend themselves if claims are made against them and the risk from the trees was Yellow Tolerable or Green Broadly Acceptable.

They were successfully able to defend claims like this when four cars were written off by an oak tree because the risk was Yellow, Tolerable and ALARP, at 1/100 000.

We're coming to end of this presentation and it's time to get back to words and numbers.

After conference I'm taking a few days R&R on the west coast of Florida.

When I'm driving along Interstate 4, I was wondering what the risk tolerance of the cops might be.



Humpty Dumpty, when talking to Alice in 'Through the Looking Glass' by Lewis Carroll, sums up the inherent problem about the ambiguous fog of words, rather than the clarity that numbers bring, very well.

At the beginning of the presentation I said I would reveal what the risk was from being hit by a piece of the UARS in numbers because none of us knew what an Extreme, High, Moderate, or Low risk was.

Few of us were comfortable about what our risk tolerance was in words.

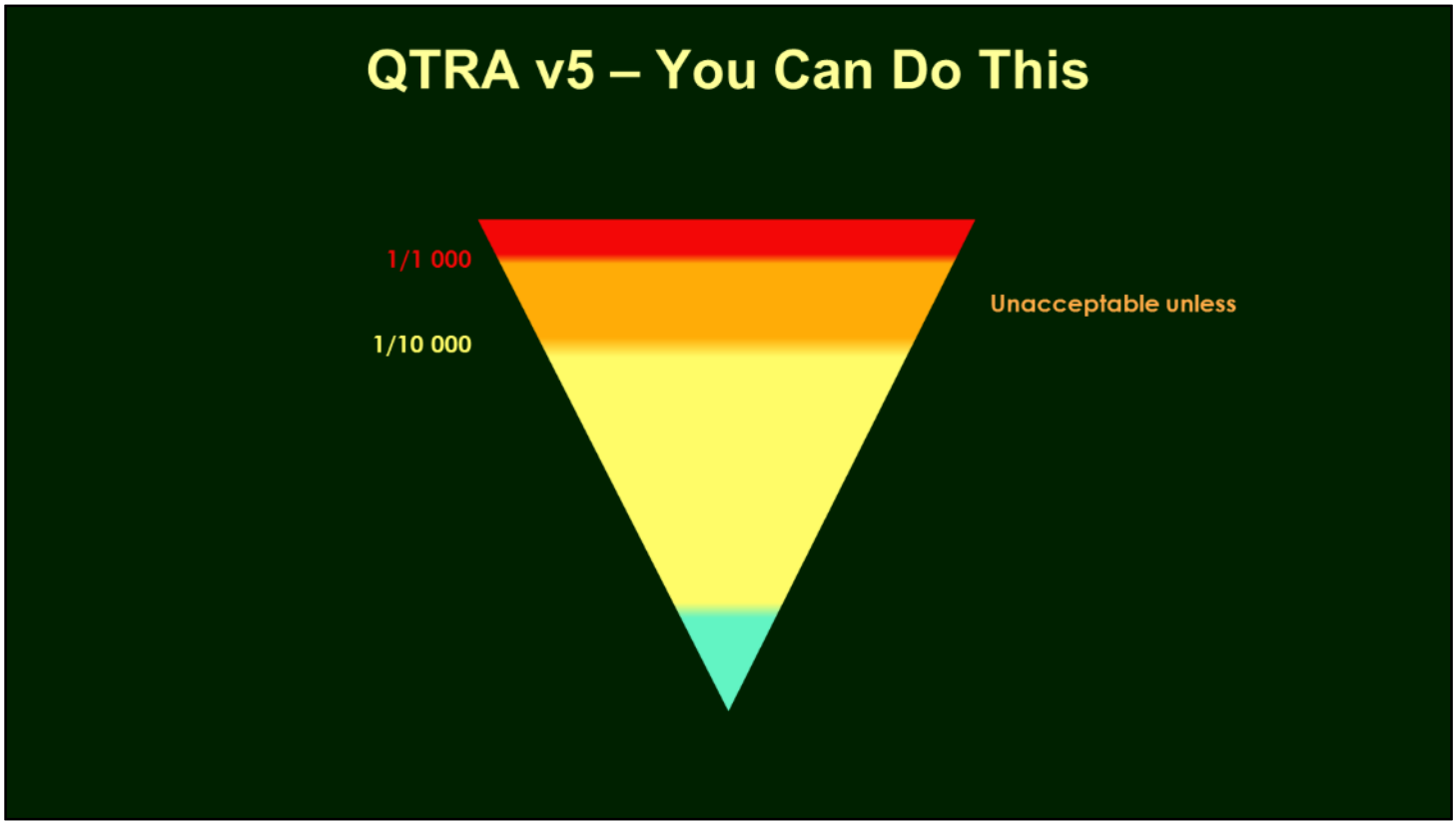
Here's the risk in numbers – 1/3 200

What's really neat about the press release this came from was the use of the word, 'just'.

JUST 1/3 200

Other coverage has it at 'as Low as' 1/3 200.

A clever bit of neuro linguistic programming because most journalists and members of the public would not be aware of ToR, or NASA's own risk tolerance thresholds, and would've latched onto the word 'just'. The word 'just', to most, would mean the risk is insignificant, a trifle, or perhaps a smidgeon.



However, when we look at the risk number 1/3 200* to bring clarity to what the word 'just' actually means, we can establish the risk from being hit by a piece of the UARS was amber as a colour, and 'Unacceptable unless' in words.

Was the risk tolerance threshold of the owner/manager (NASA) Extreme, High, Moderate, or Low for the risk they imposed of being hit by a piece of the UARS?

I have no idea because the meaning of those words are 'impeded by ambiguity' and lack any agreed definition. They are open to widely different interpretations depending on who says them, and who hears them.

…..

* If you were paying really careful attention, or take the time go back and review the opening slides, you'll see the launch year in numbers was 1991, and the NASA 1/10 000 risk tolerance threshold policy year in numbers was 1995. Since 1995 NASA have designed their satellites so when they fall back to earth, no one piece that survives re-entry will be big enough to cause a risk greater than 1/10 000.

What are the advantages and benefits of using QTRA v5 to the risk assessor and to the risk owner/ manager?

QTRA enables the risk assessor to measure risk in a language that is clear, unambiguous, and is defined by colours, words, and numbers.

QTRA enables the risk owner/manager to manage the risk they impose from their trees to widely agreed and accepted risk tolerance thresholds.

QTRA enables the risk owner/manager to consider the risk, costs, and benefits from their trees when they are allocating limited financial resources.

Where does QTRA go next?

Following my exchanges with NASA, I've been in discussion with a recently formed private space agency called Star Command Inc about how to quantify tree risk with higher confidence and lower uncertainty.

I recently had a meeting with their CEO.

A certain Mr Lightyear.

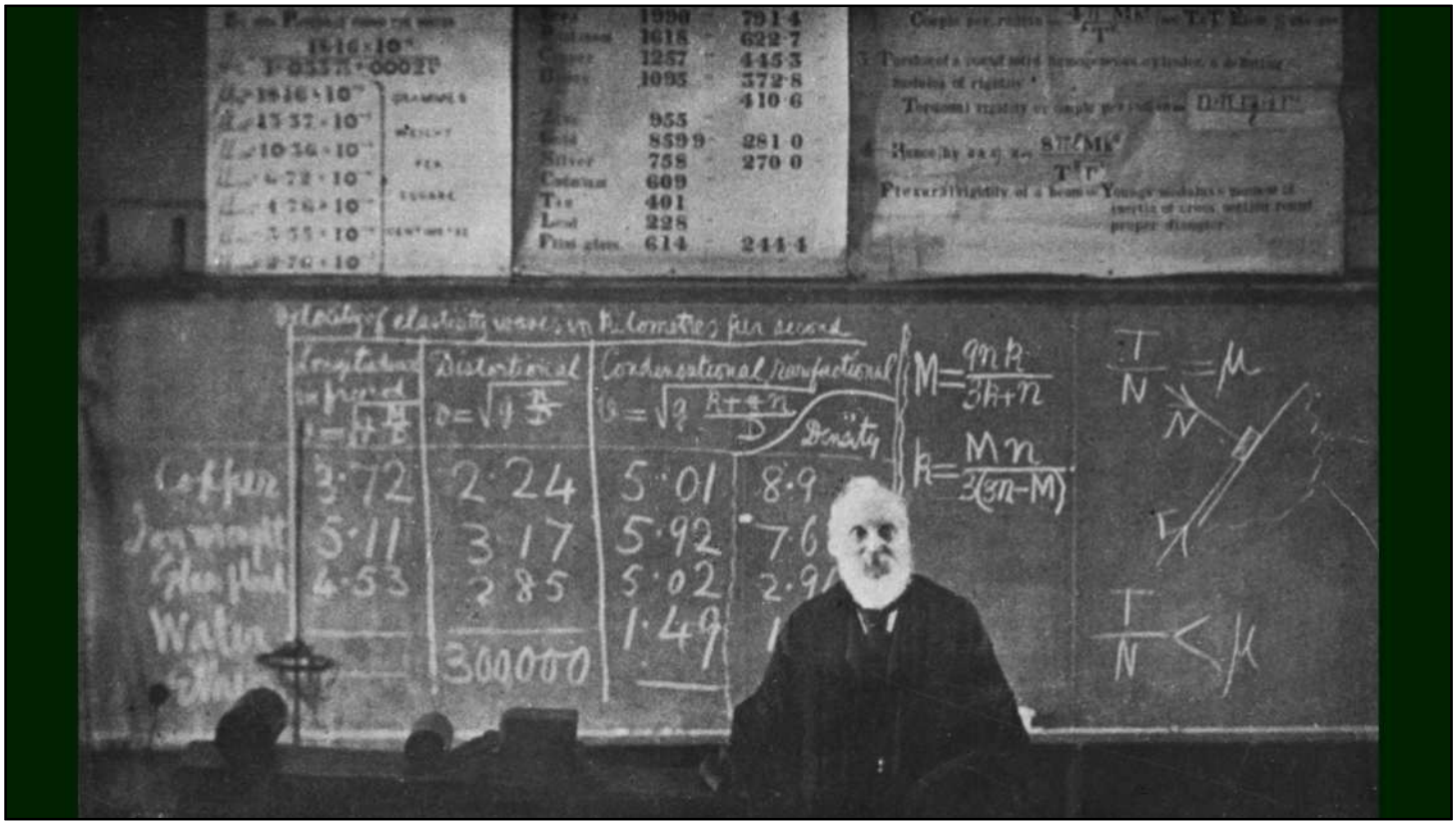
He has suggested QTRA go to infinity and beyond.

Though a fantastic sounding adventure, it has too much never-ending uncertainty.

QTRA v5 is currently being reviewed by a panel and v6 is planned.

The VALID guidance to assisting with Probability or Likelihood of Failure will be rolled out before a version change, and is currently undergoing field trials.

We began this presentation with some words about numbers, and we're going to finish with some more words about numbers.



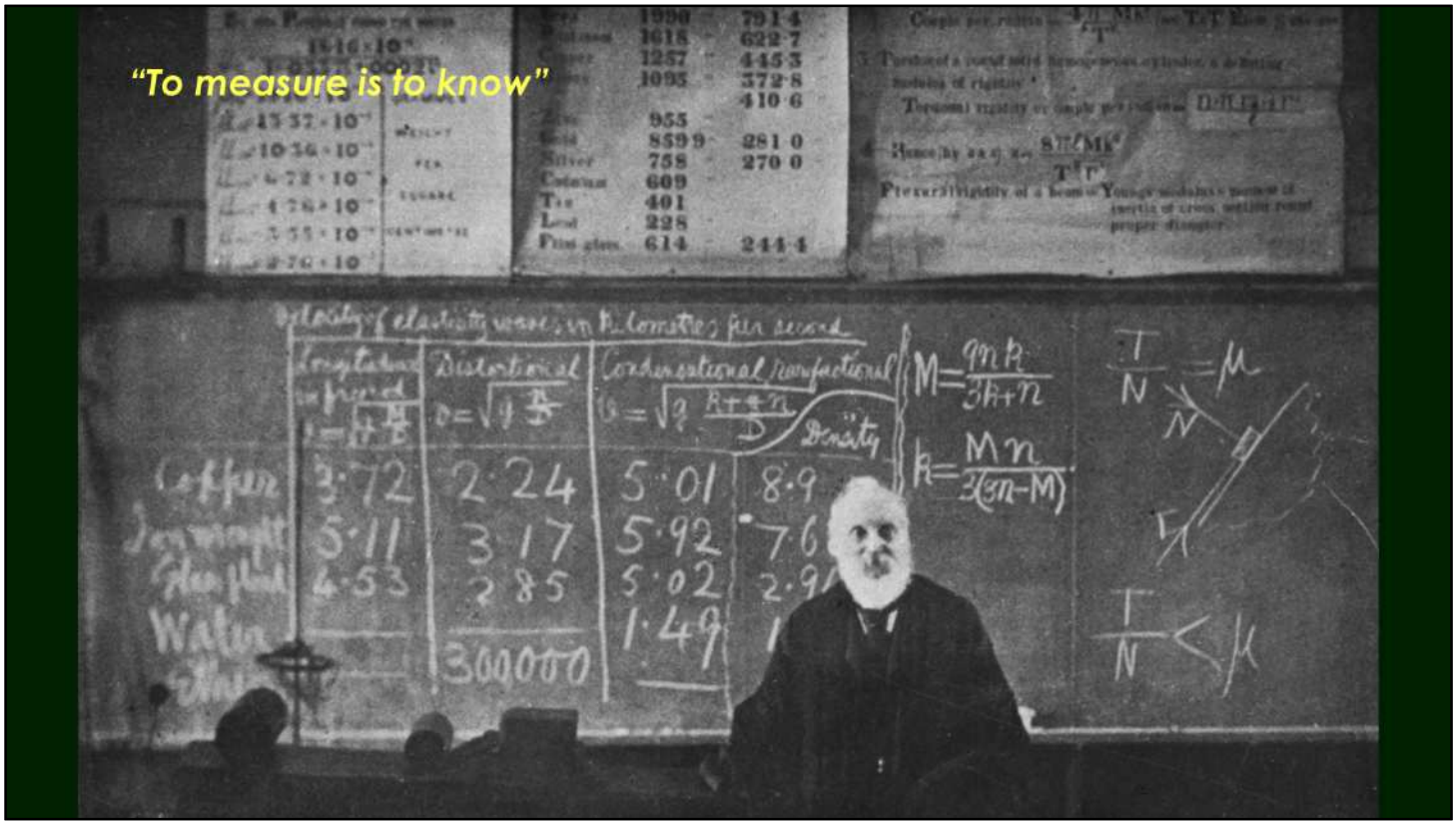
This is Lord Kelvin.

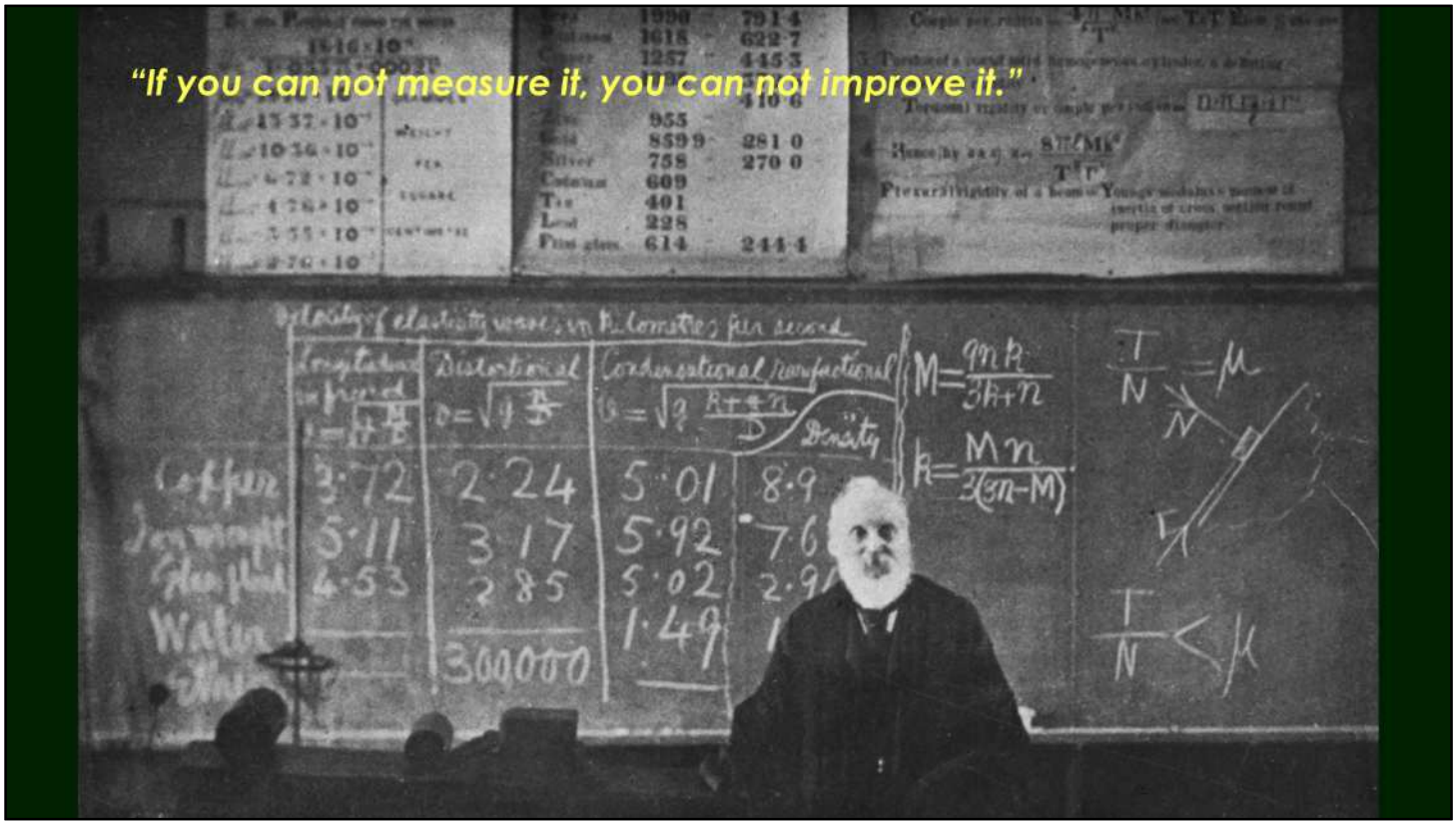
He's a famous scientist who had the absolute measurement of temperature named after him.

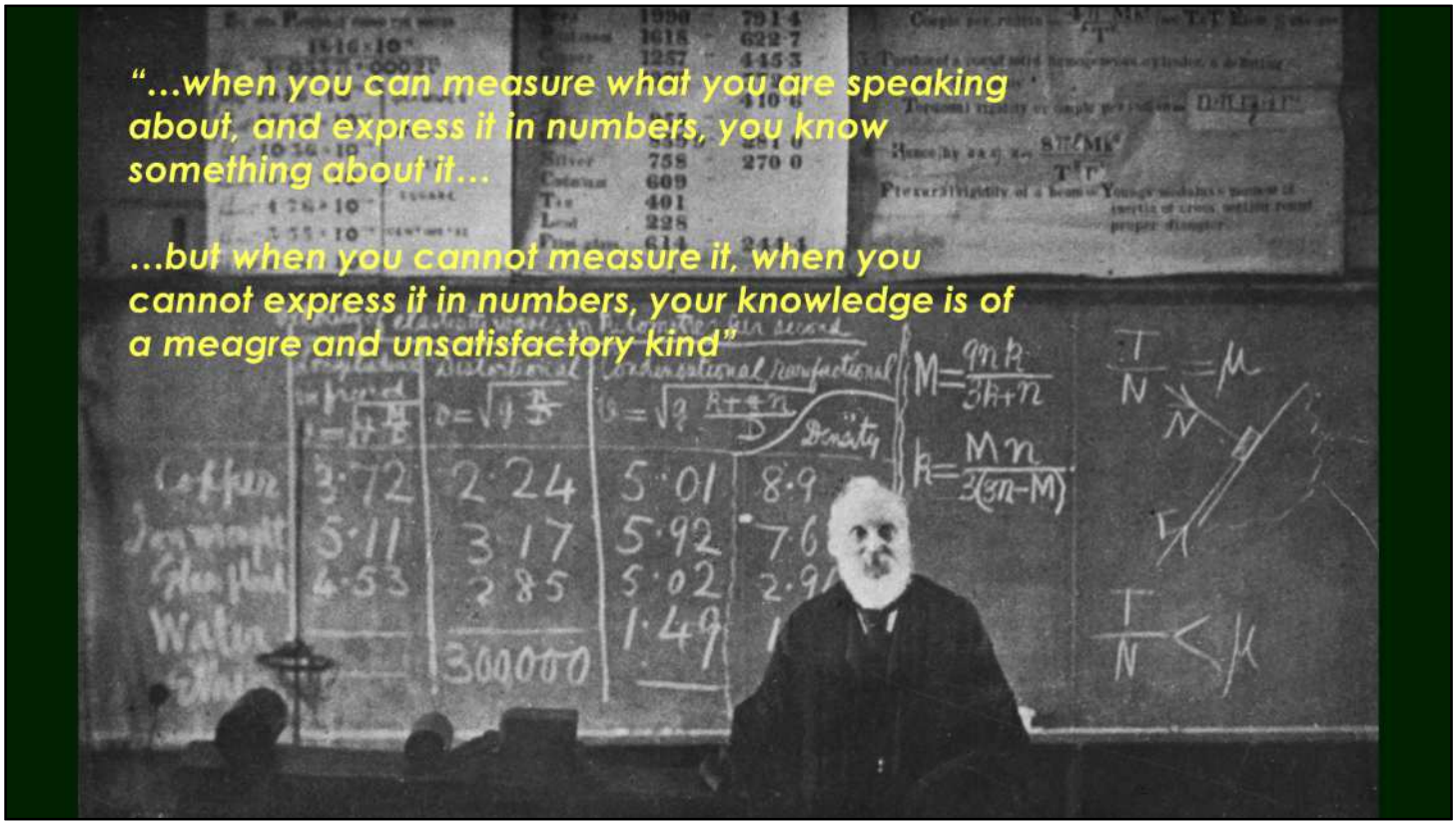
Here he is trying to work out the fairest way to divide up a restaurant cheque when more than three people dine.

The photograph captures him just at that tricky point in the calculation where he's dealing with shared side dishes and an unaccounted for glass of wine.

He's one of history's great scientists and measurers, and on the subject of words and numbers he said the following.


"To measure is to know"


"If you can not measure it, you can not improve it."


"…when you can measure what you are speaking about, and express it in numbers, you know something about it…
…but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind"

Thank you for listening to my presentation, it's been a pleasure.

Any questions?

If you want to know more about how QTRA can benefit the risk assessor and risk owner/manager, please visit the website.

If you have any questions about this presentation, it would be good to hear from you. Please feel free to email me.

david.evans@arborcentre.co.uk

For those of you who might be interested, I've been searching for compatibility and common ground between QTRA and TRAQ since I was asked to have a look at this by some TRAQ accredited arborists in early 2014, when running some training workshops in Australia.

The screen grab above is from a UK discussion forum called Arbtalk where you can download a document that lays out where I've got so far.

http://tinyurl.com/o3f4gjd

Or search "Arbtalk TRAQ & QTRA – Compatibility and Common Ground"

If you have any comments or contributions to make about the discussion document, it would be great to hear from you either on a forum or by private email.

Cheers

David