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THE ART OF DECISION MAKING

Professor Nira Chamberlain OBE

September 2024

AtkinsRéalis

THEME:
RISK, PROBABILITY, COST & A BIT OF AI

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Abstract

- The role of a cost model is to enable a successful project outcome.
- Risk and probability has an important part to play in this.
- When we fully understand the very nature of risk and probability, it helps us in the Art of Decision Making.

Question

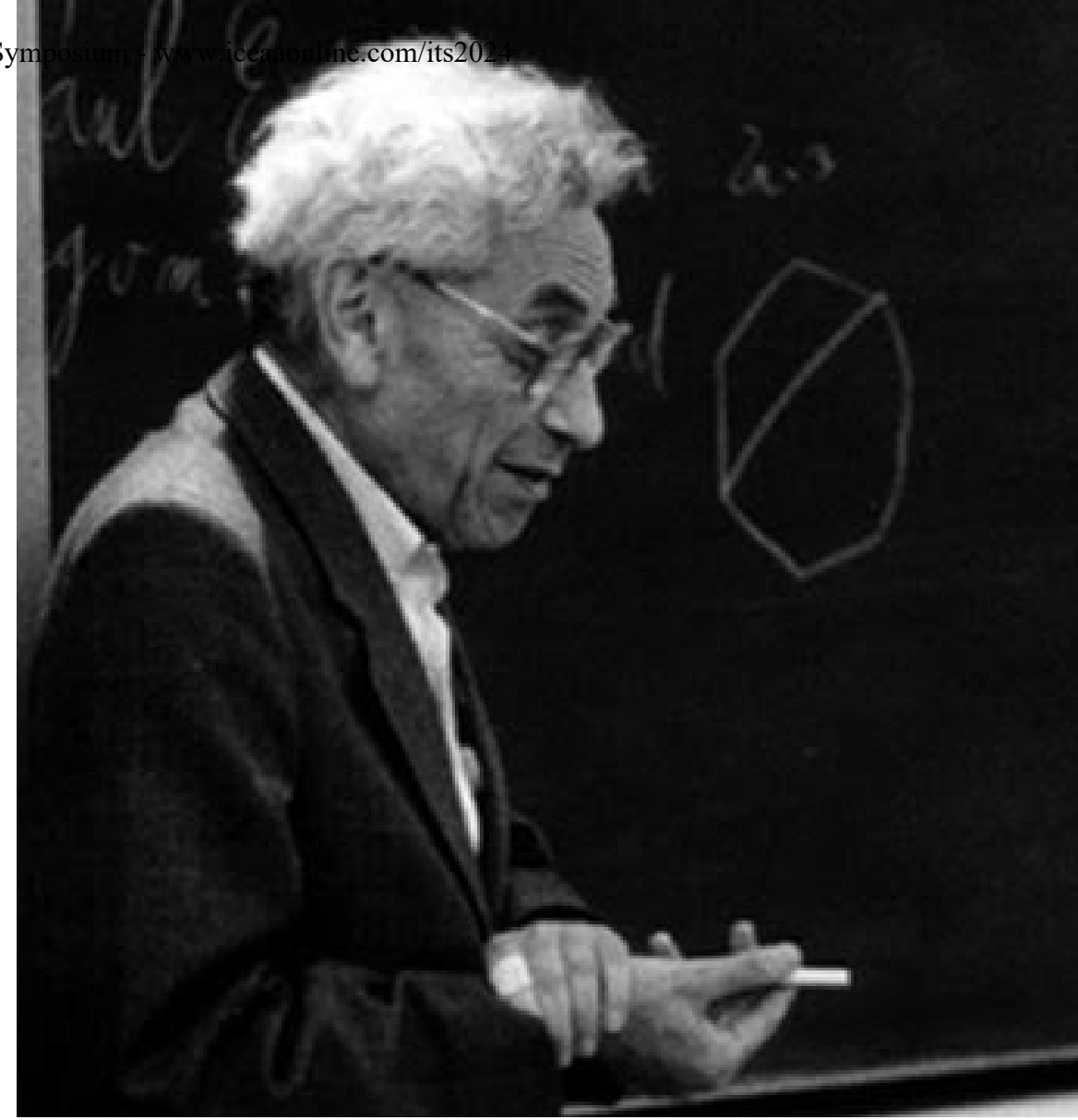
- Suppose you're on a game show, and you're given the choice of three doors:
- Behind one door is a car; behind the others, goats.
- You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat behind it.
- He then says to you, "Do you want to pick door No. 2?"
- **Is it to your advantage to switch your choice?**

Raise your hands

For those who got it wrong

- So did

1. Paul Erdos – one of the greatest mathematicians of all time.
2. 1000 PhDs
3. So many others as well …..
4. I will reveal the answer later



Decision Making

- There are many decisions making made before, during and after a cost modelling project.
- Making the right decision at each stage is critical for best outcomes.
- But what is the art of decision making?

Decision Making

There are many decisions making done before, during and after a cost modelling project.

Making the right decision at each stage is critical for best outcomes.

But what is the art of decision making?

Logic and/or intuition

Logical vs. Intuitive Processing

- Process information in a linear, sequential, logical manner
- Uses information piece by piece to solve problem
- When reading/listening look for pieces to draw logical conclusions
- Decisions based on logical proof

- Use intuition
- Get right answer to maths problem, but not sure how you arrived at answer
- Start with answer and work backwards
- Decisions based on feelings

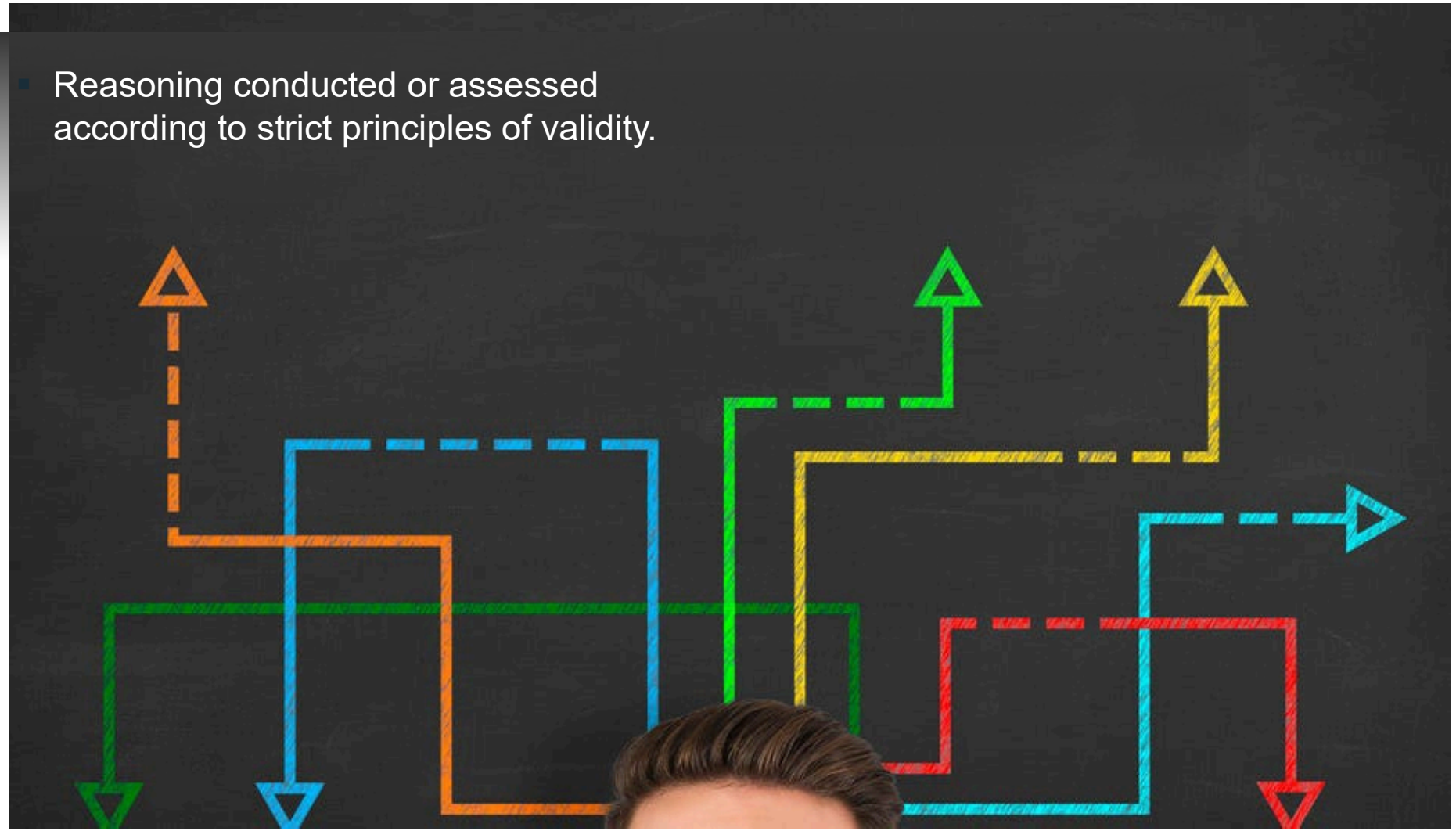
- Ref: Should You Trust Logic and Data or Gut Feelings to Make Decisions? | by Ray Williams | Medium

The Art of Decision Making – Intuition

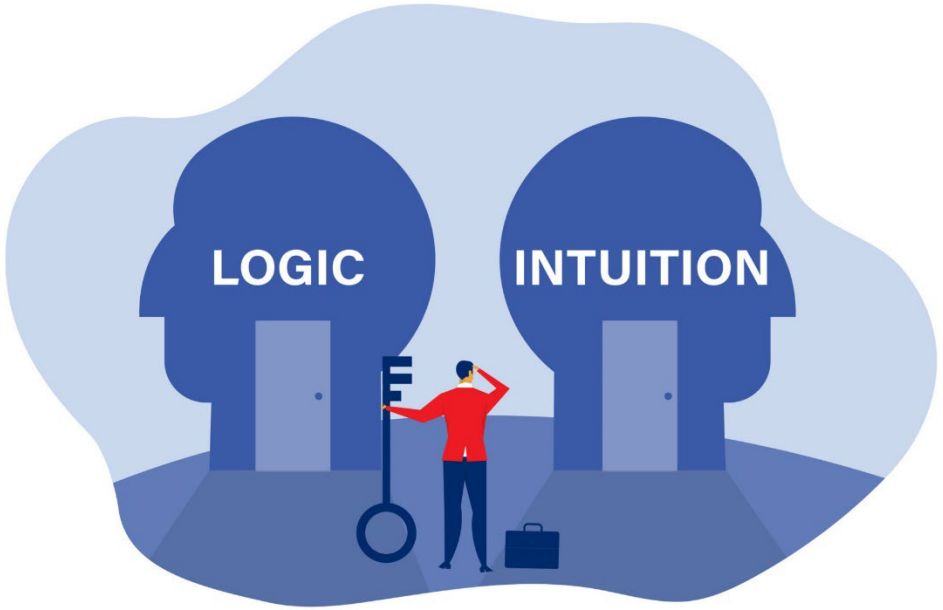
The ability to understand something instinctively, without the need
for conscious reasoning.

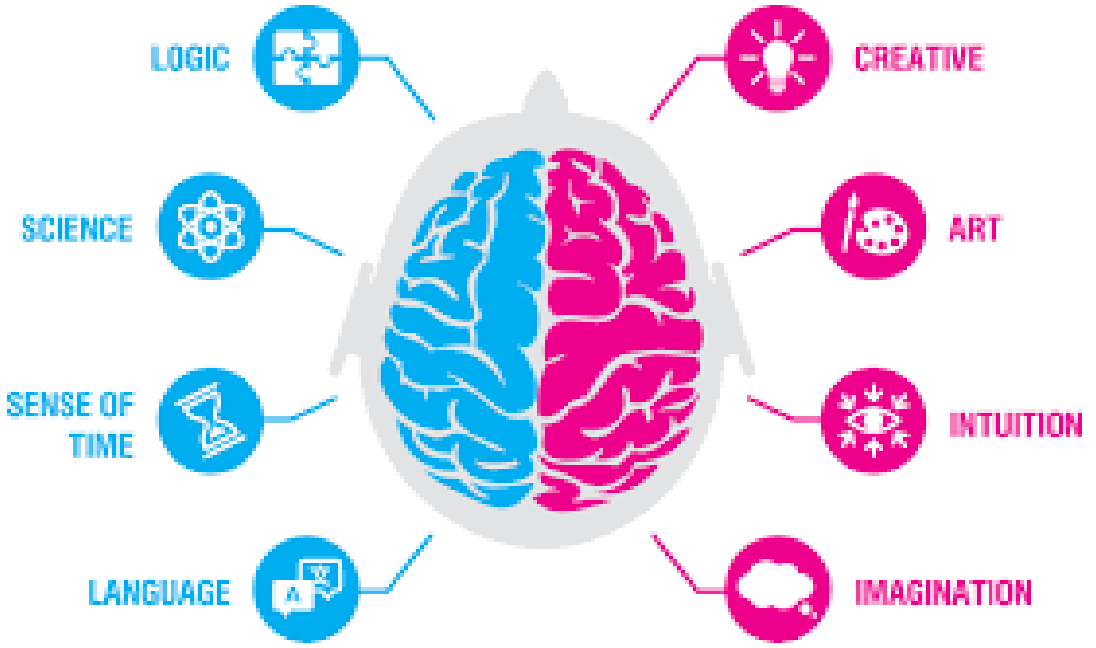
The Art of Decision Making – Logic

- Reasoning conducted or assessed according to strict principles of validity.



We tend to believe our Decision Making is Logical rather than intuition





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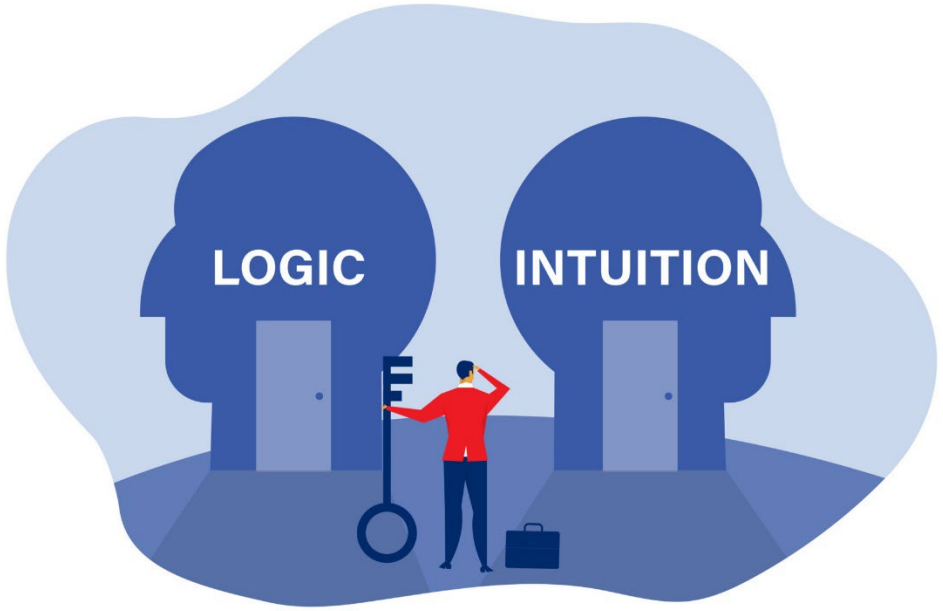
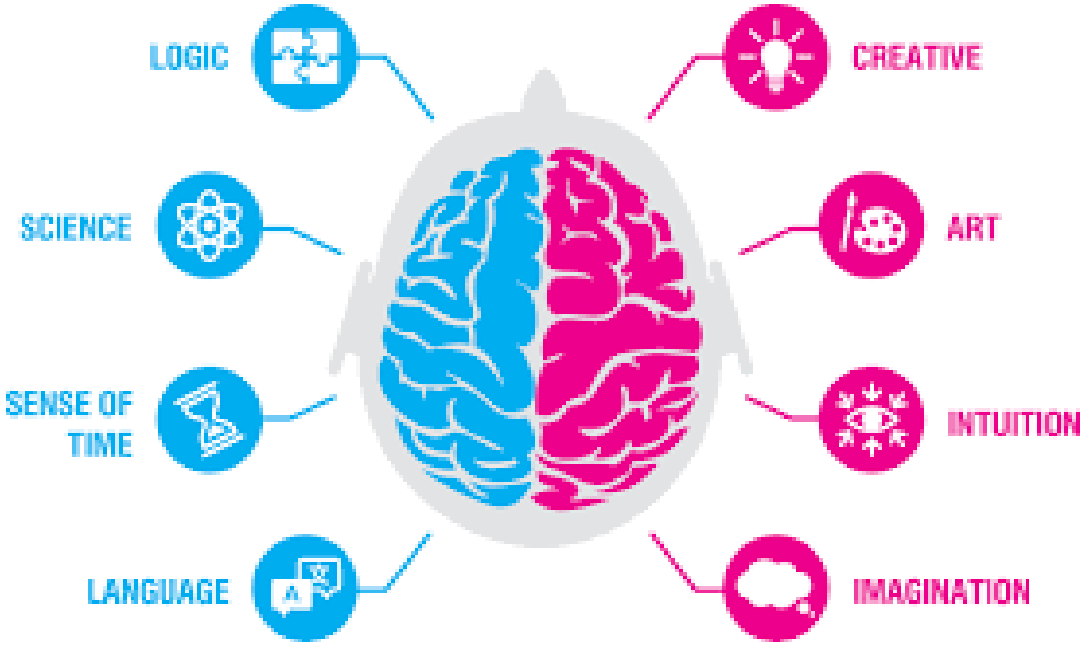
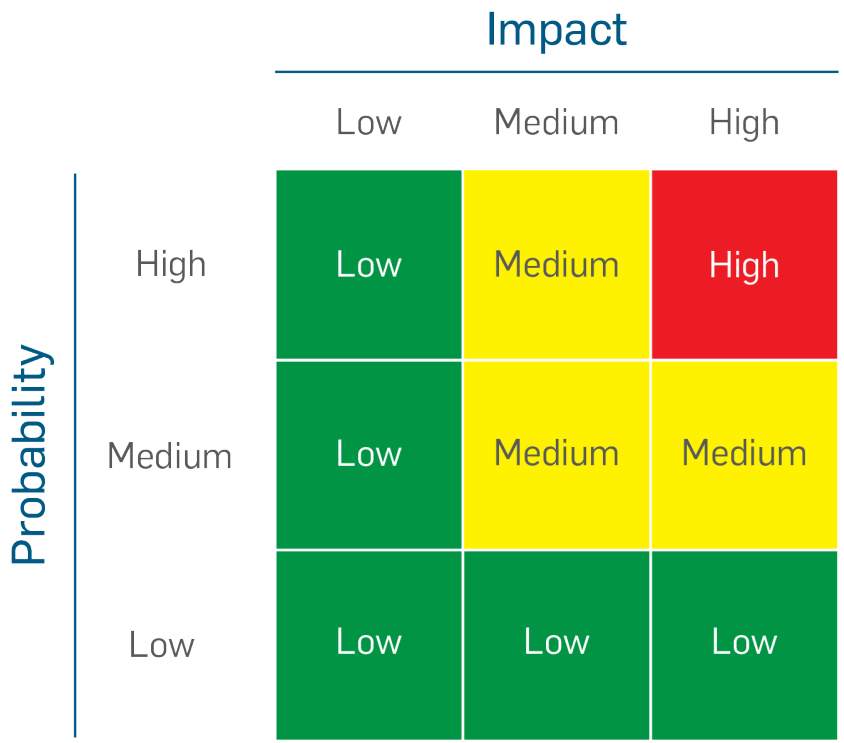




We tend to take a mixed approach

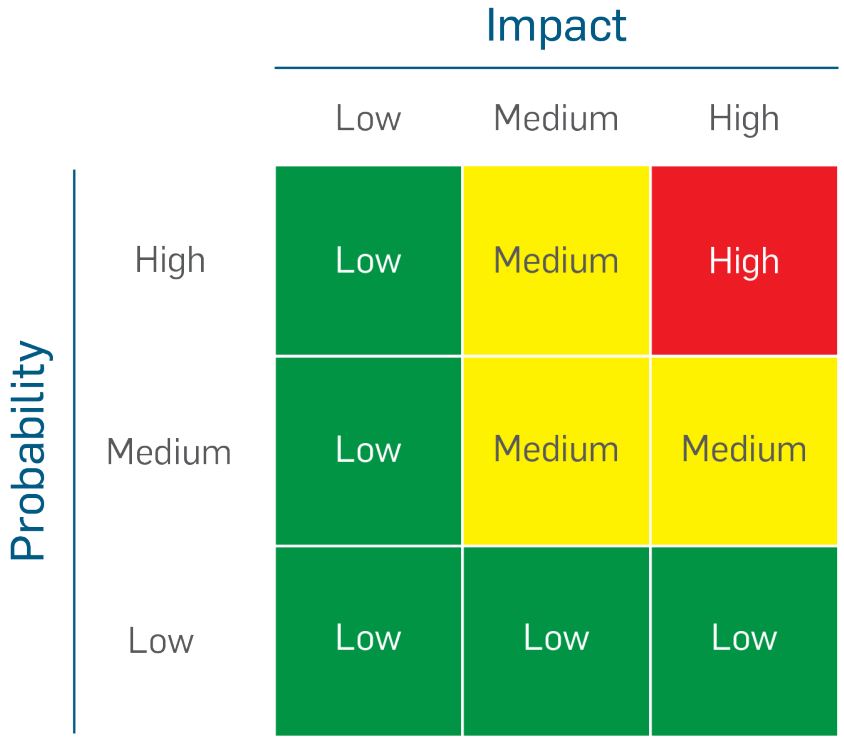
The assessment of Risks is an important part of Decision Making



INTUITION

Will represent probabilities as high, medium and low and give it a value.

Cost Modelling and the Representation of Risks



INTUITION

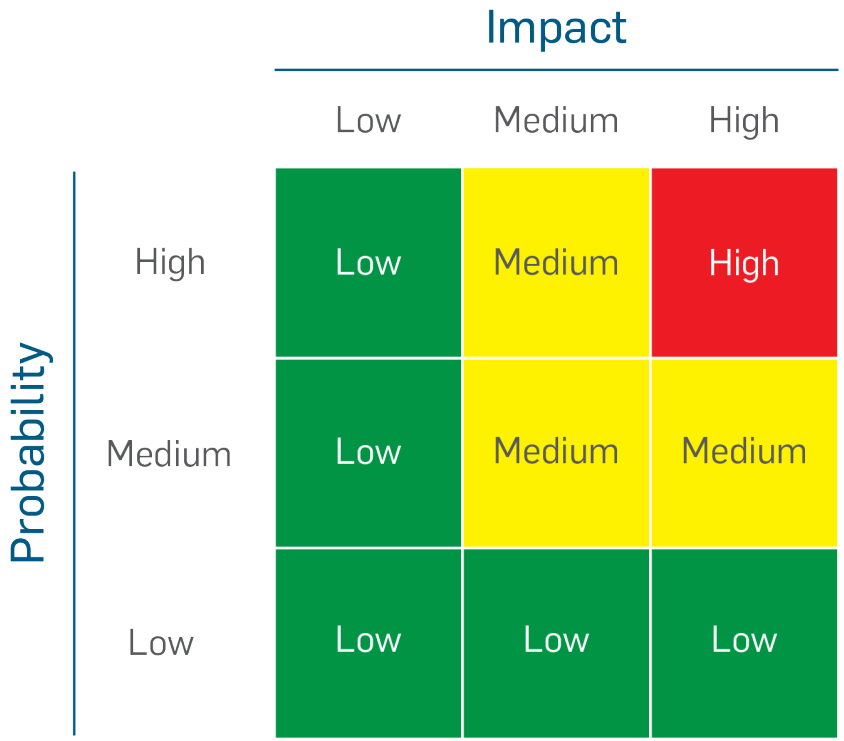
Risks are most likely where projects will fail.

UK defence spending + Add to myFT

MoD accused of overspending as budget 'black hole' hits £17bn

Watchdog censures department over fourth successive unaffordable equipment programme

Cost Modelling and the Representation of Risks



INTUITION

Is Intuition the right way to represent probabilities?

- "No clear end in sight" to HS2 cost or delays with "many difficulties ahead".

22 September 2021

Fictious example but the problems are real

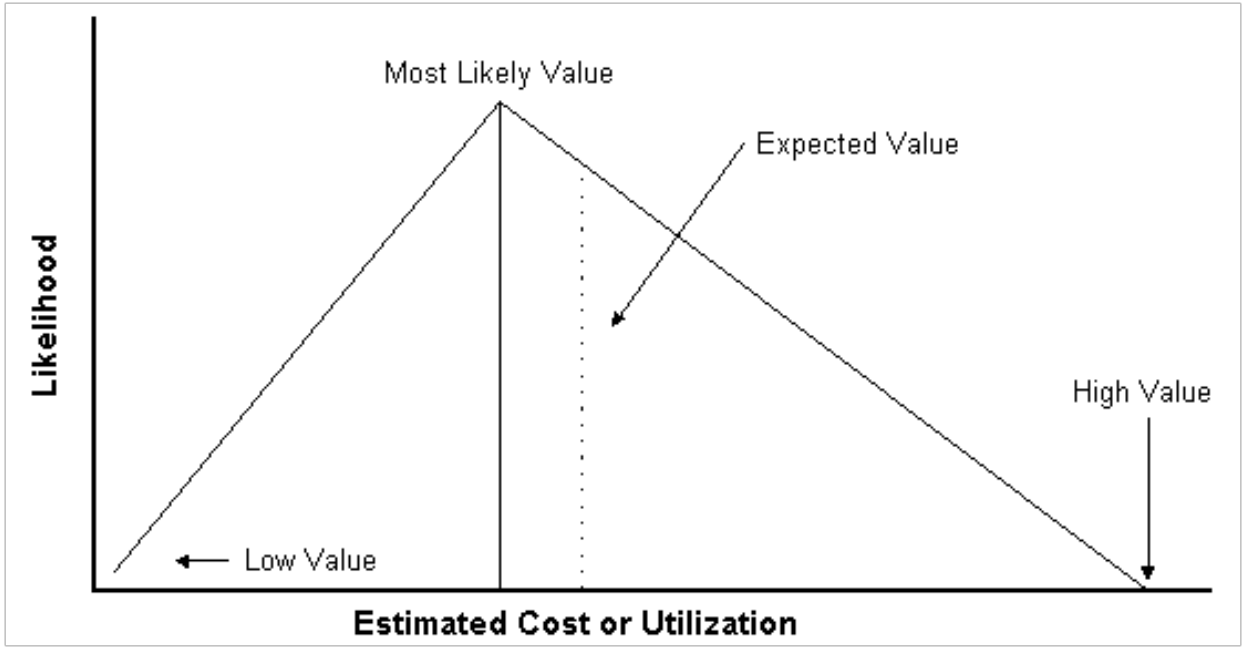
A client wants to ride a rollercoaster that costs £8 per ride.
Each ride, the rollercoaster will play one of six musical tunes at random.

The client wants to continually ride the rollercoaster until they have heard all six tunes.

What is the Risk Budget we should we set aside?

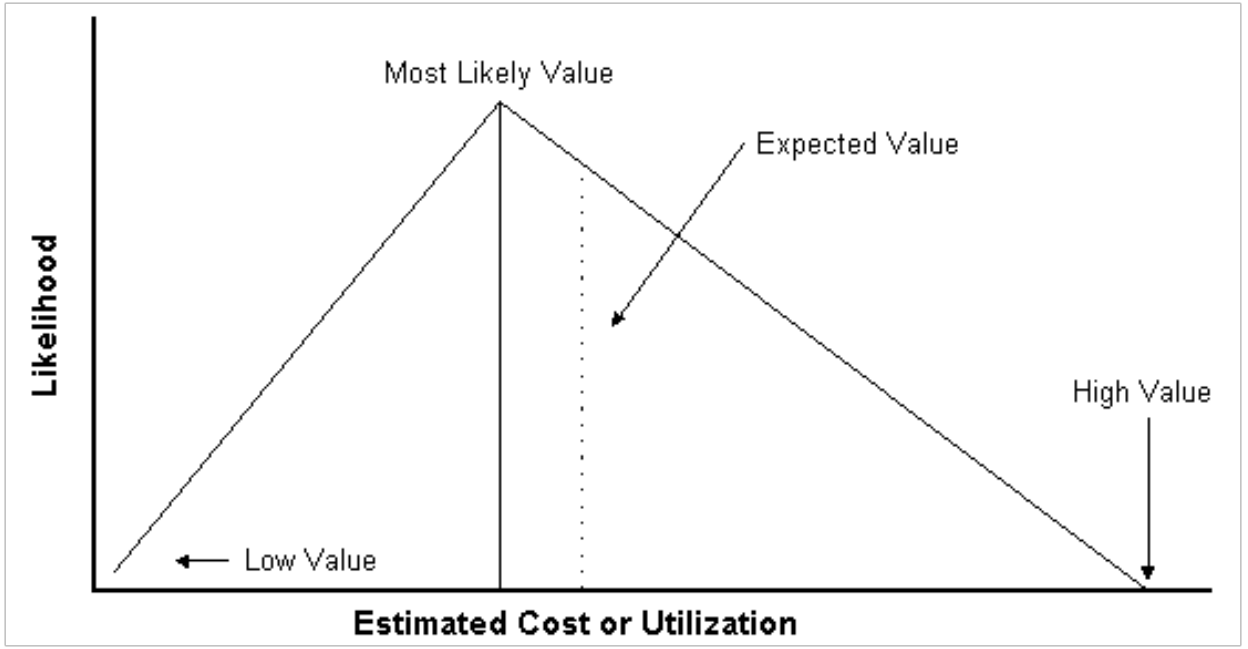
Three Points Estimates

- Pure Intuition, we would just guess
- Using Logic and Intuition
- **The Low Value** must be 6 x £8 = £48. The Client must need to ride the
  roller-coaster at least six times



Three Points Estimates

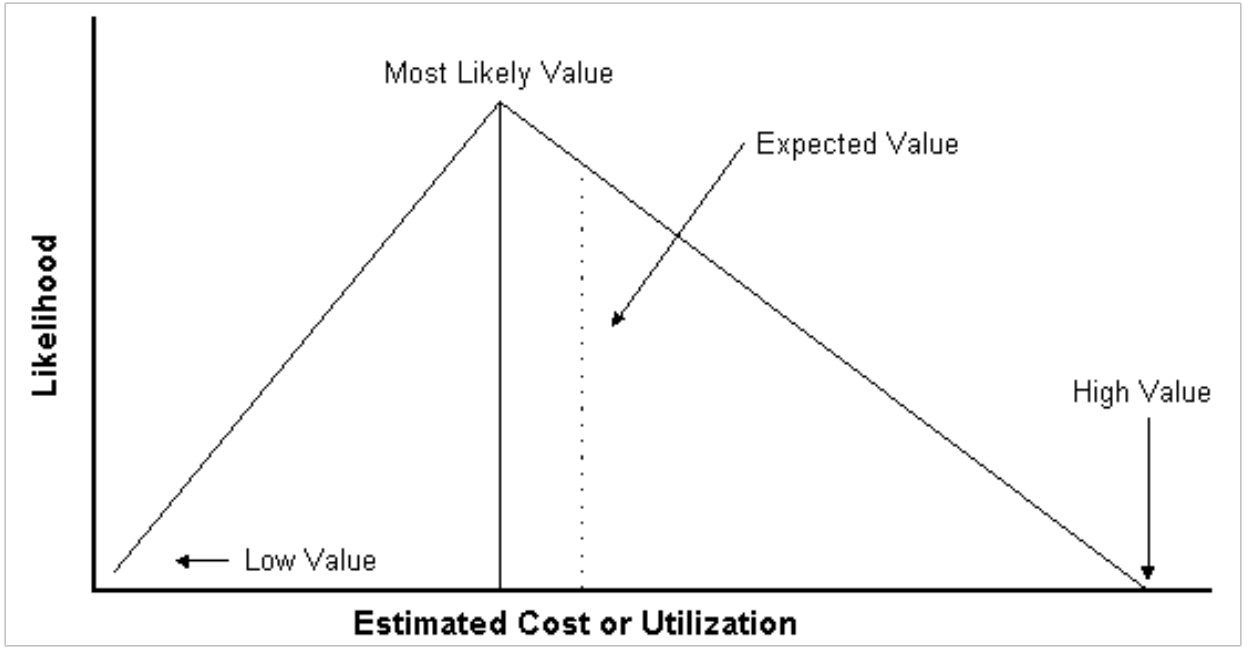
- Pure Intuition, we would just guess
- Using Logic and Intuition
- **The Expected Value a little bit harder**
- A way of working average number of rides is invert the probability of hearing song number 1,2, 3, 4, 5 & 6 and then add these values together. Hence average number of rides = 6/1 + 6/2 +6/3 + 6/4 +6/5 +6/6 = 14.7. Rounding this to the nearest whole number is 15
- 15x £8 = £120



Three Points Estimates

- Pure Intuition, we would just guess
- Using Logic and Intuition
- **The High Value is ….**

- Hard to calculate – as probabilities is not intuitive



Three Points Estimates

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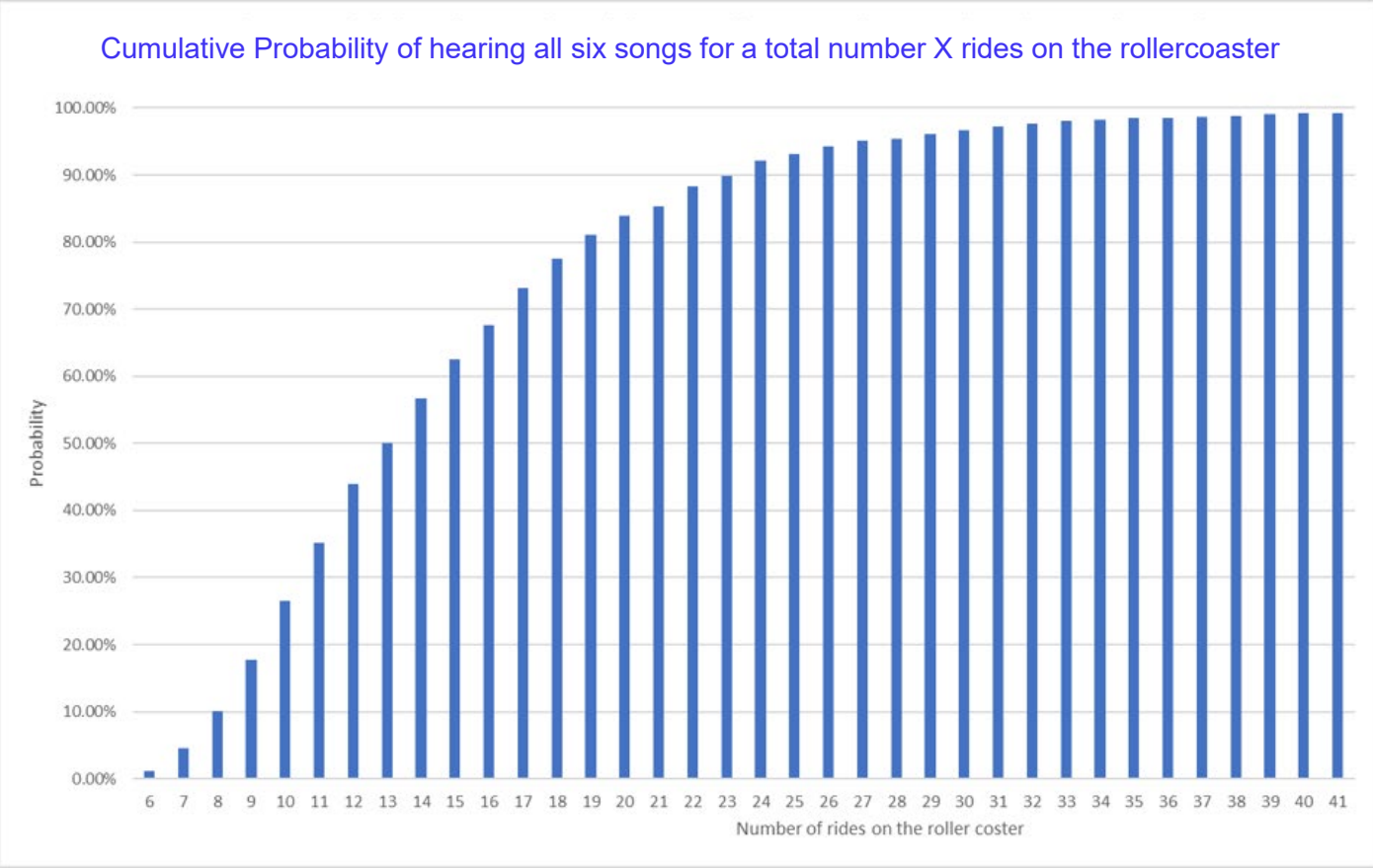
- A monte-carlo simulation can help produce an approximate distribution



Low probabilities

- There is a possibility (low probability) of our client staying on the roller-coaster for a long (infinite) time!

- **A low probability is still a probability and can occur!**

That was fun but here is a real life example

(the maths is similar)

- **The Repair Loop of APT**
- **What did History tell us?**
  - Maiden journey 1981.
  - Engineers spent more than two years making technical modifications.
  - Withdrawn in 1984.

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The Repair Loop of APT

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Why was it withdrawn?

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The Repair Loop of APT

What did History tell us?

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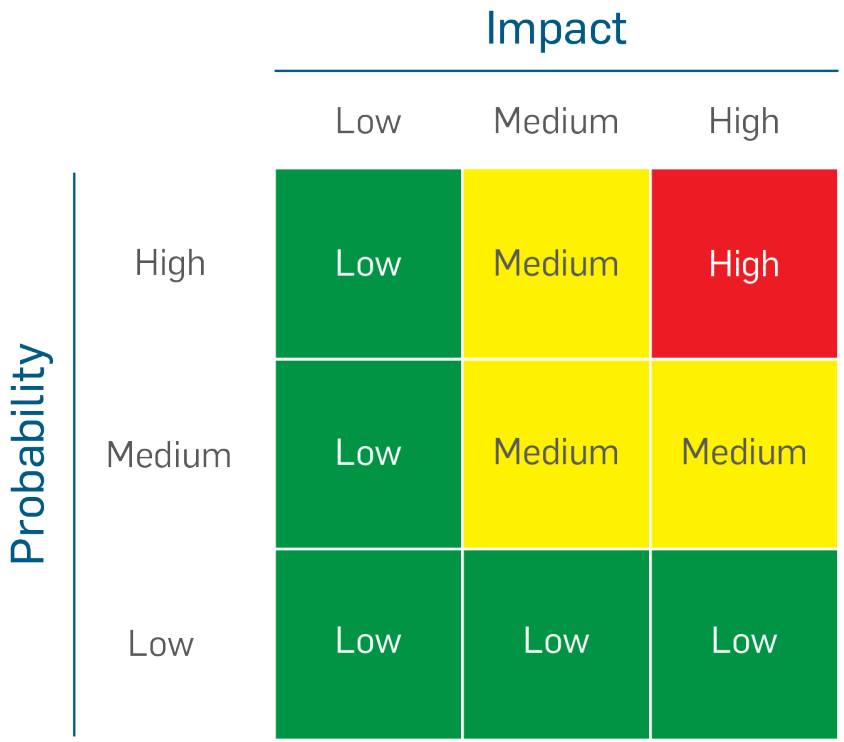
Why was it withdrawn?

- **The Low probability events occurred.**

Where is Low Probability but High Impact?

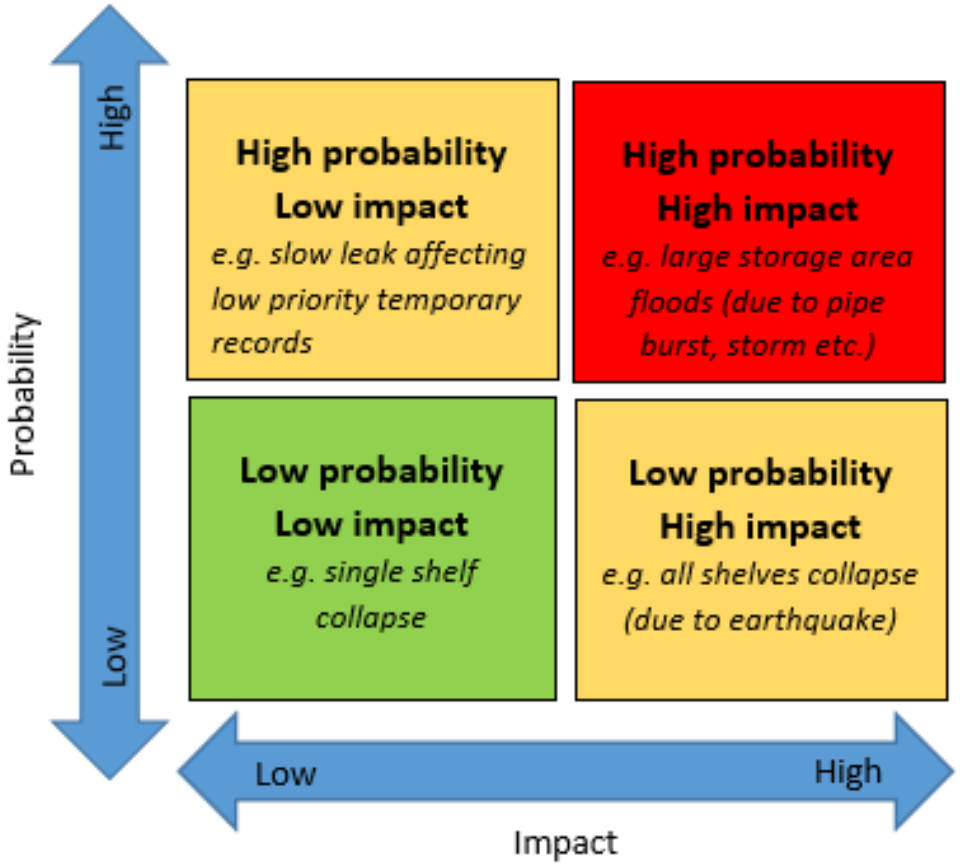


INTUITION

Is Intuition the right way to represent probabilities?

- Crossrail over budget again, report reveals

Where is Low Probability but High Impact?



INTUITION

Can Intuition account for Black Swan Events?

Should Black Swan Events be ignored?

Example of a Low Probability and its Misconception

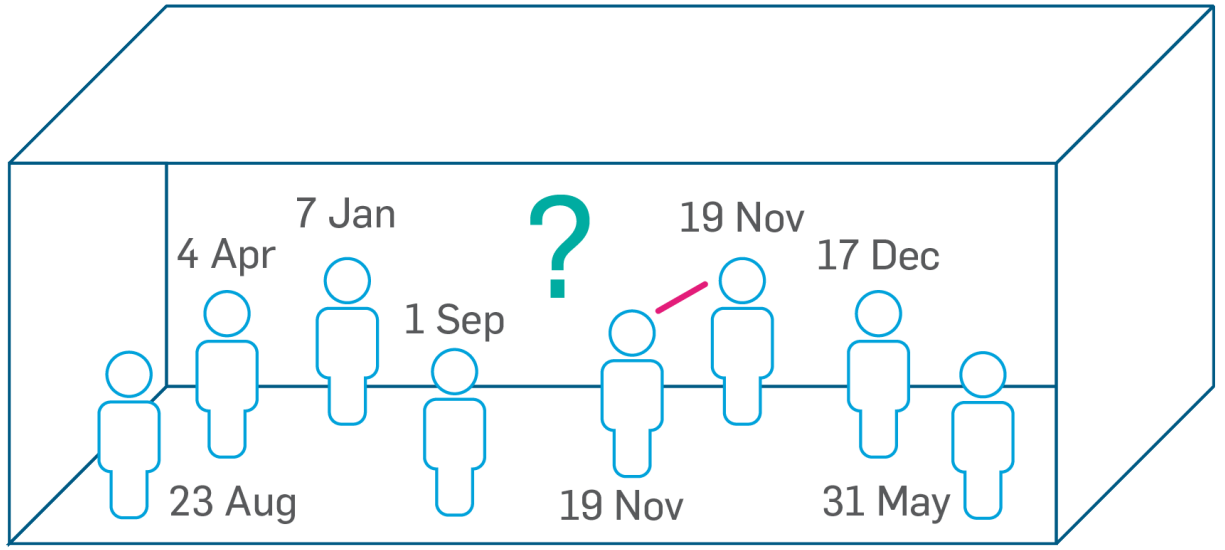
- Just because an event has a low probability, it doesn't mean that event will never occur.

- If those events do occur, to the client it will not feel like a low probability.

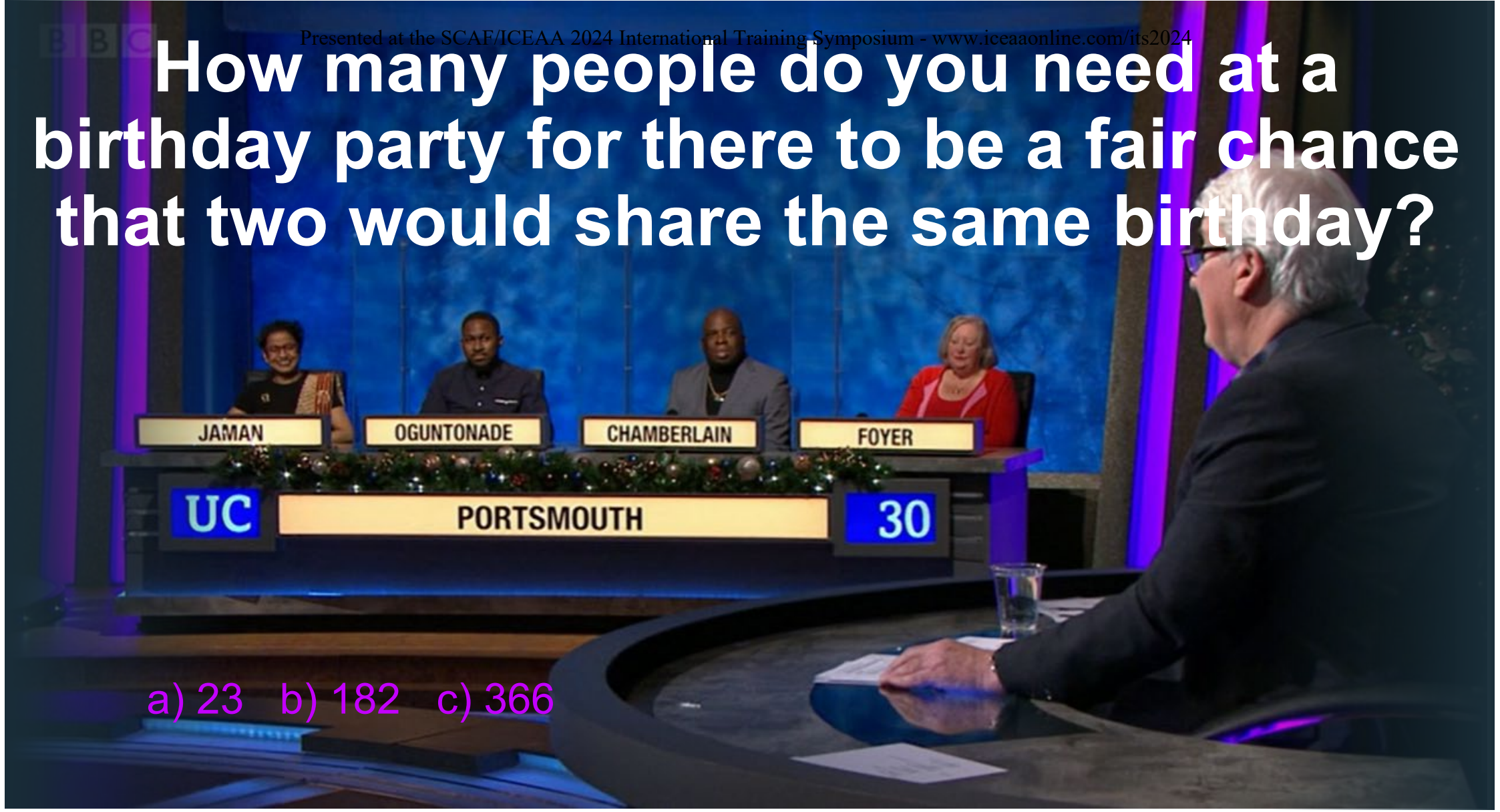
Is Probability Intuitive?

- What are the chances that two people share a birthday in a group of 23?

The Birthday Paradox



How many people do you need at a birthday party for there to be a fair chance that two would share the same birthday?



a) 23 b) 182 c) 366

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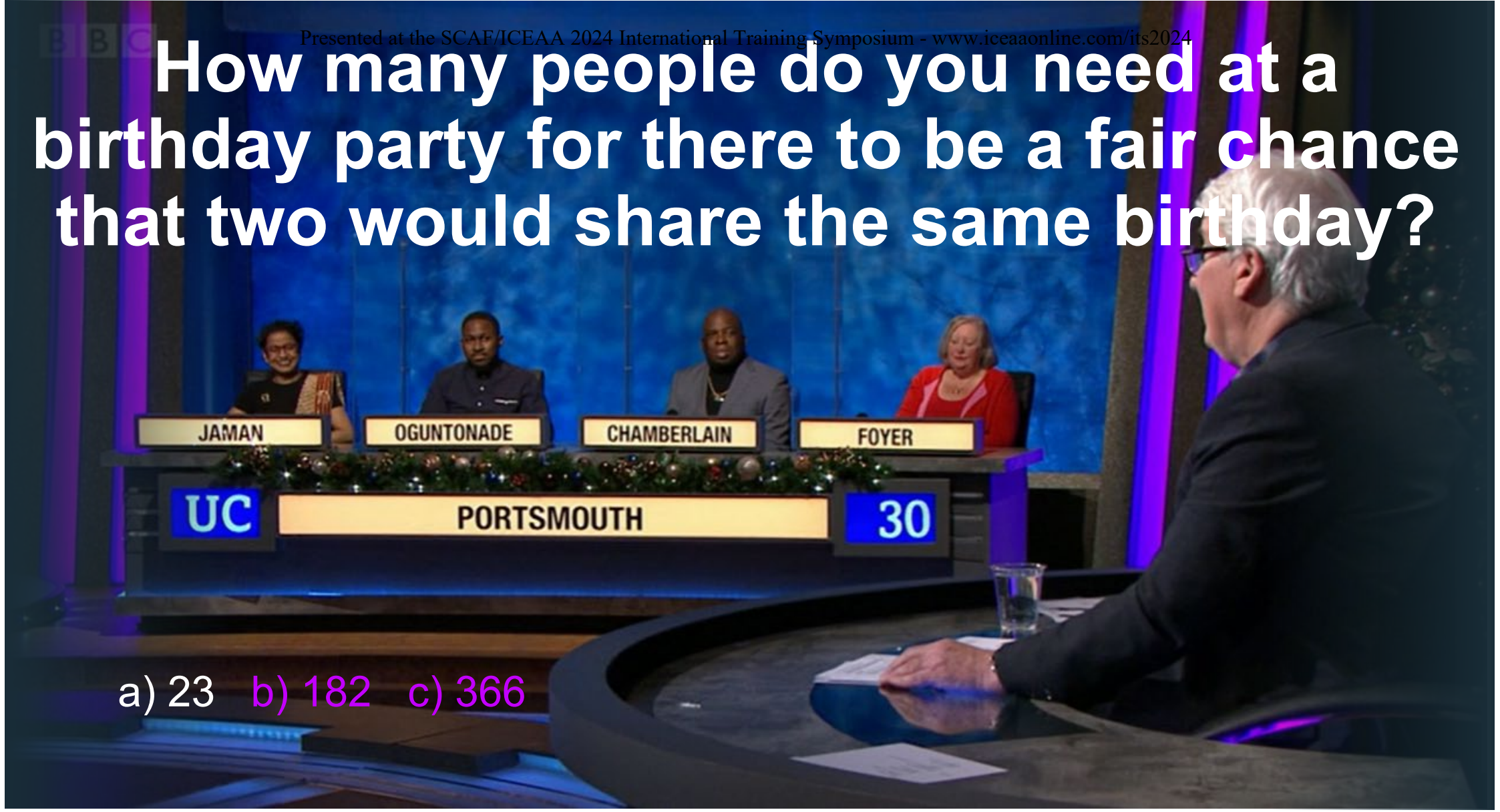
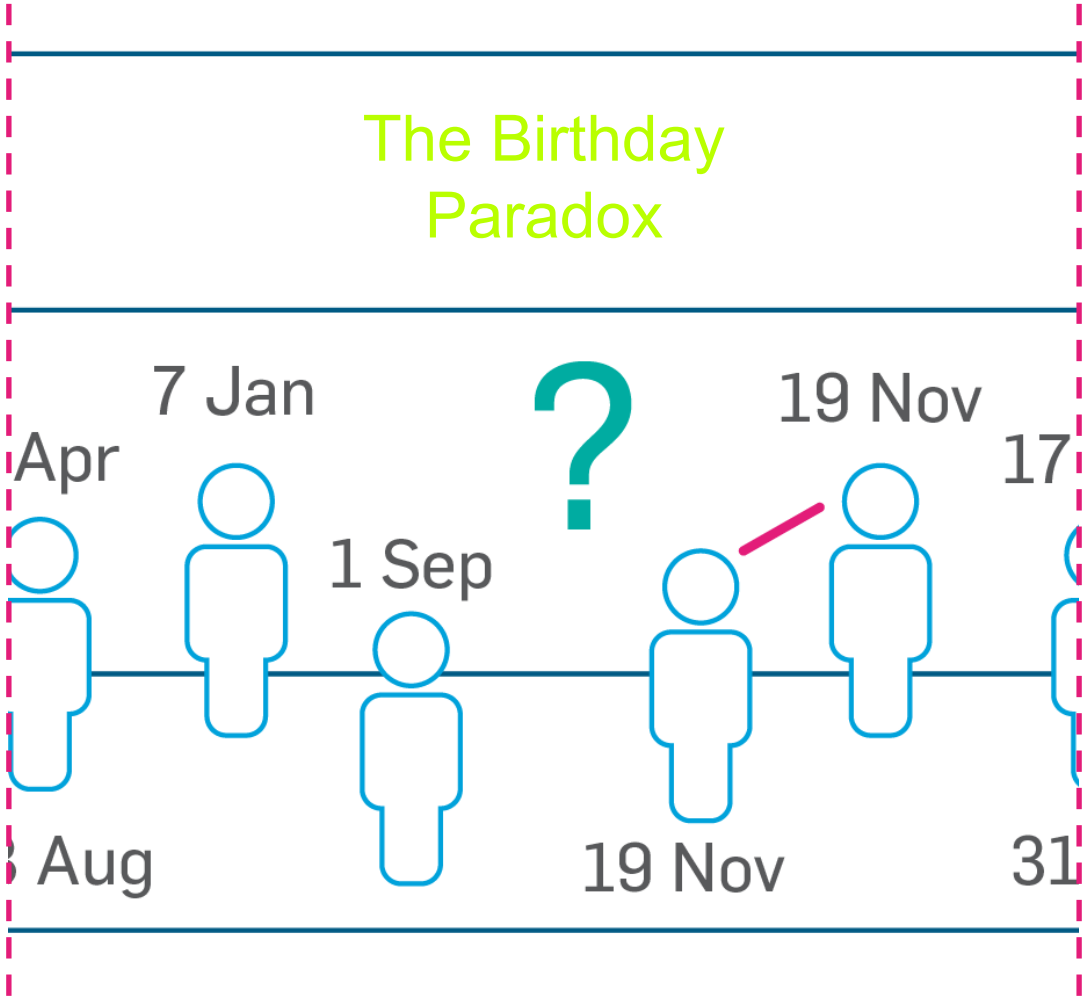


a) 23 b) 182 c) 366

The birthday problem demo and explanation

Tell me the date of your Birthday.

Hold your hand up if your Birthday is on the same day!



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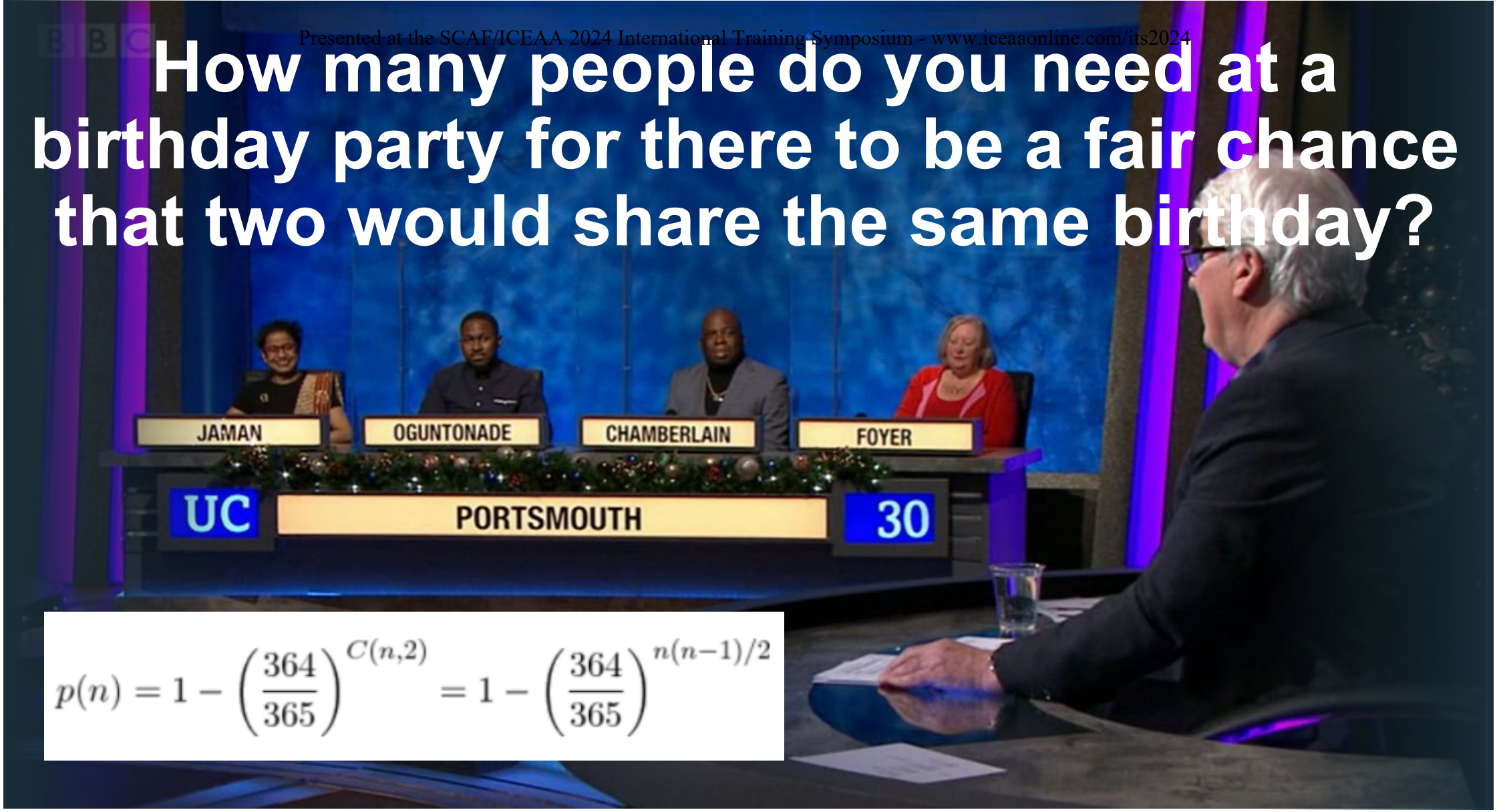


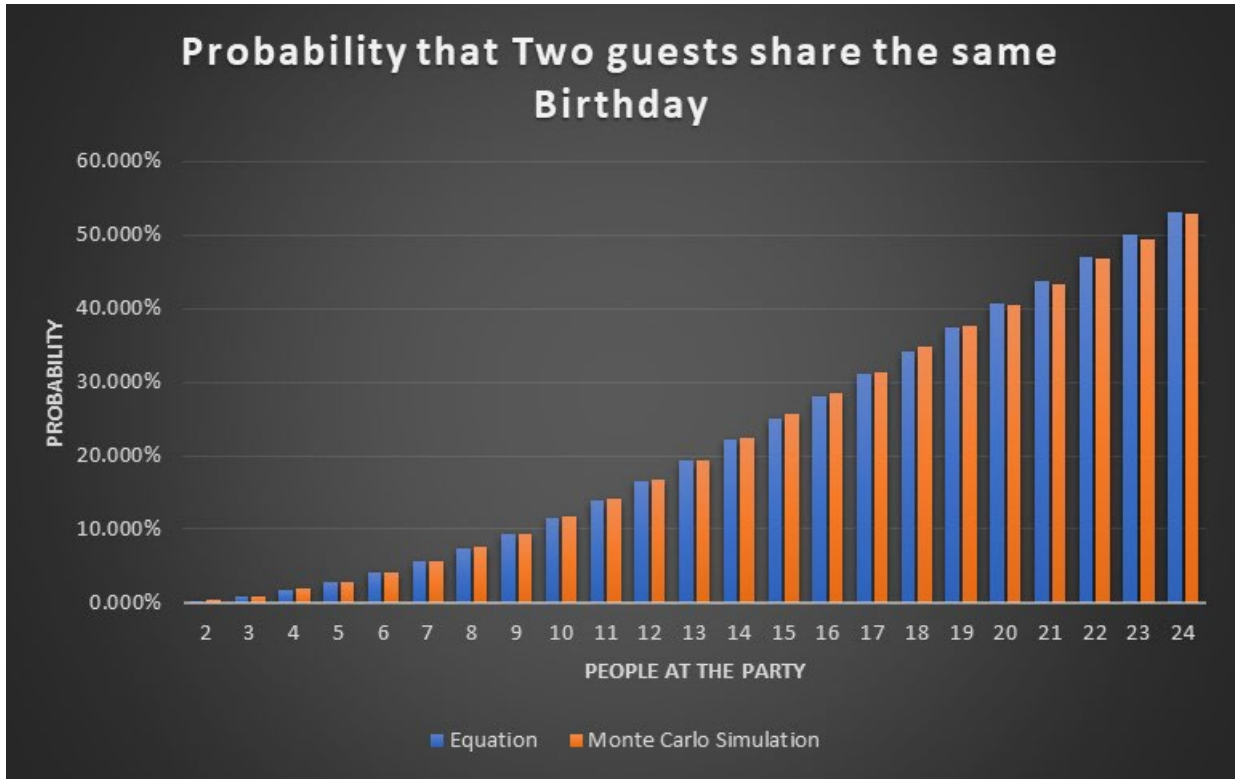
$$p(n) = 1 - \left(\frac{364}{365}\right)^{C(n,2)} = 1 - \left(\frac{364}{365}\right)^{n(n-1)/2}$$

Equation versus Monte-Carlo Simulation

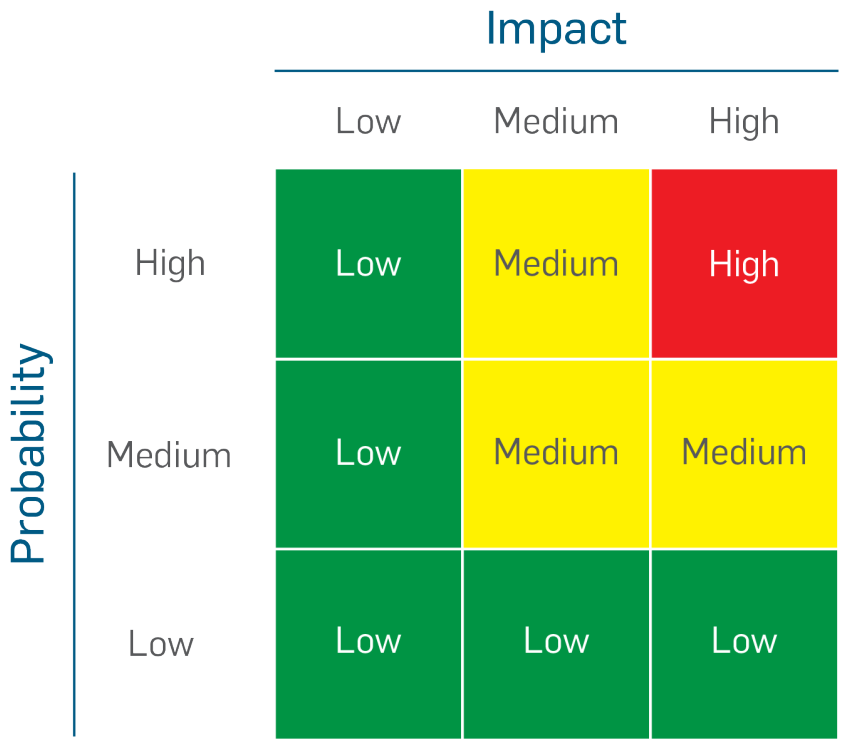
$$\bar{p}(n) = 1 \times \left(1 - \frac{1}{365}\right) \times \left(1 - \frac{2}{365}\right) \times \cdots \times \left(1 - \frac{n-1}{365}\right)$$

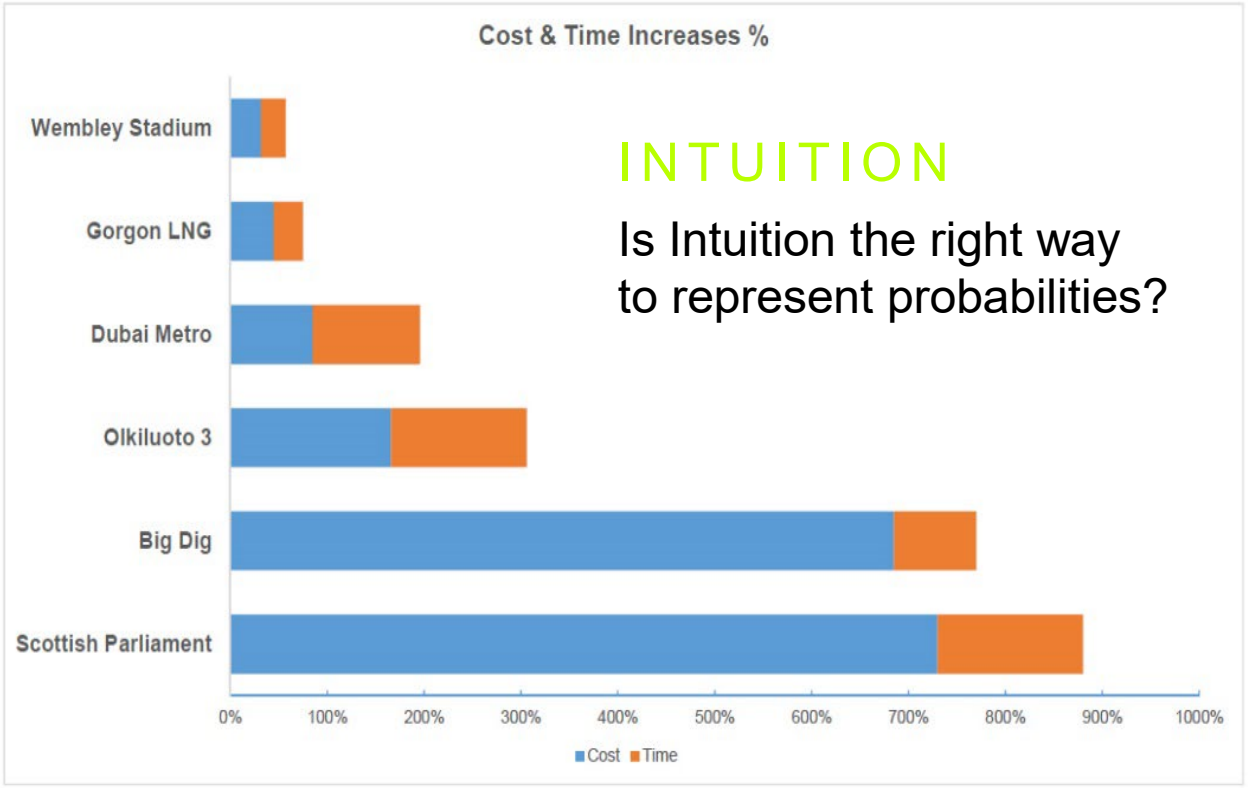
$$= \frac{365 \times 364 \times \cdots \times (365 - n + 1)}{365^n}$$

$$= \frac{365!}{365^n (365 - n)!} = \frac{n! \cdot \binom{365}{n}}{365^n} = \frac{{}_{365}P_n}{365^n}$$

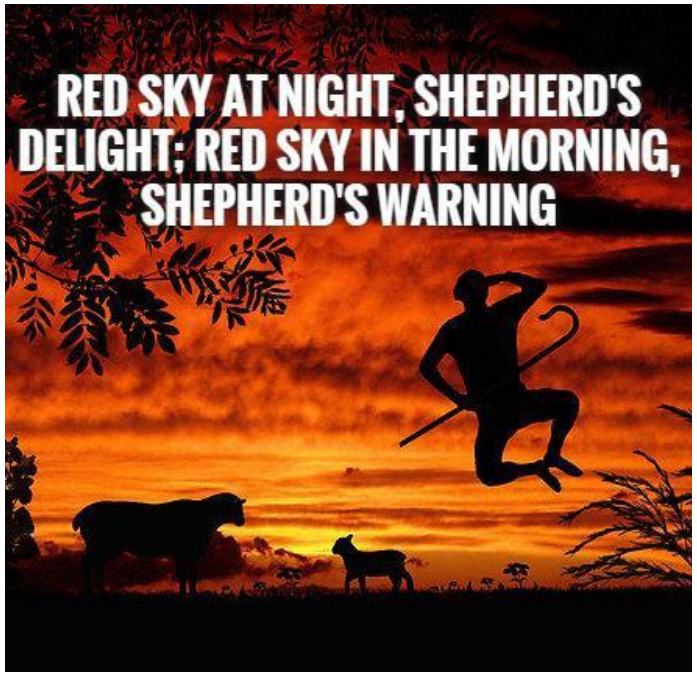


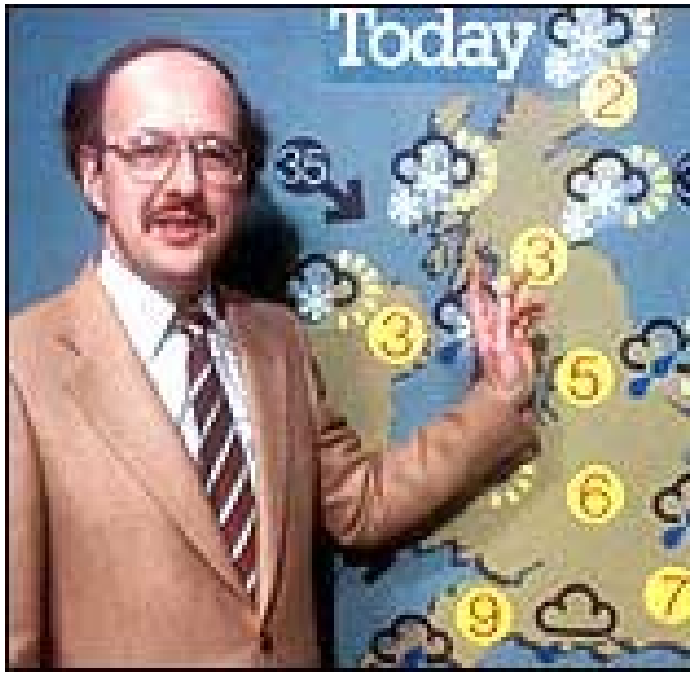
If Probabilities are not intuitive why are we using it in this way for Risks?

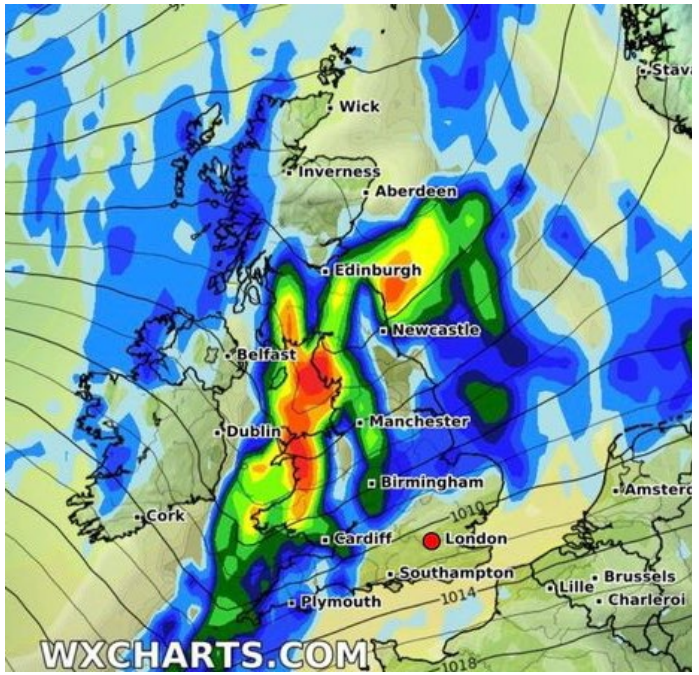




Lessons learnt from the Weather Forecast



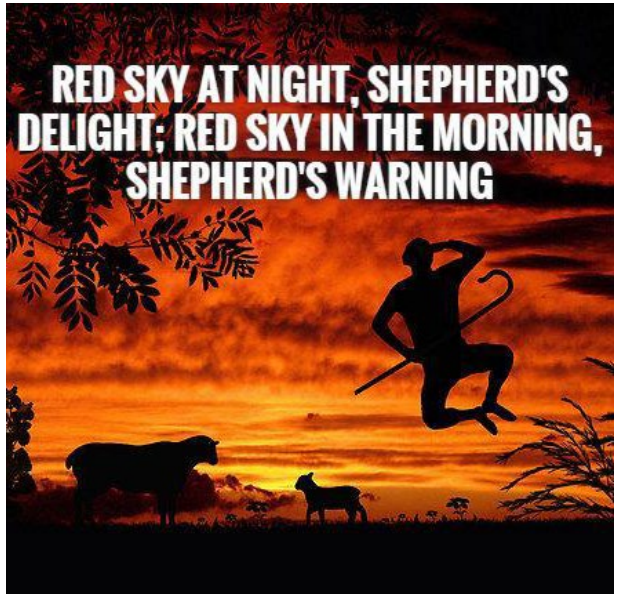


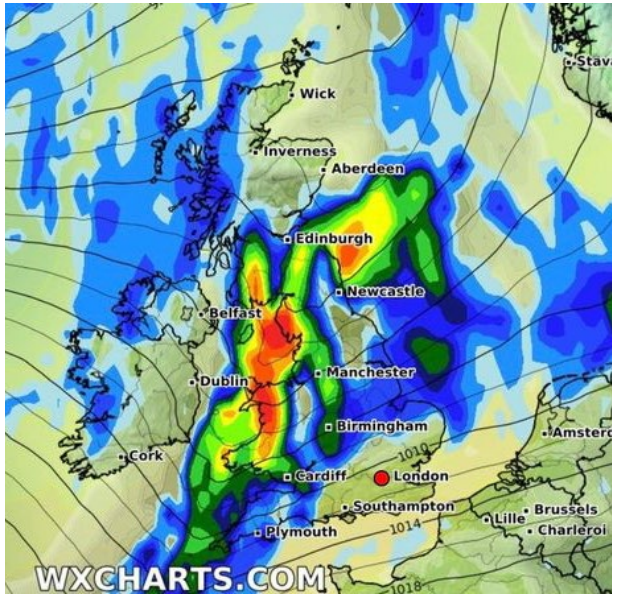


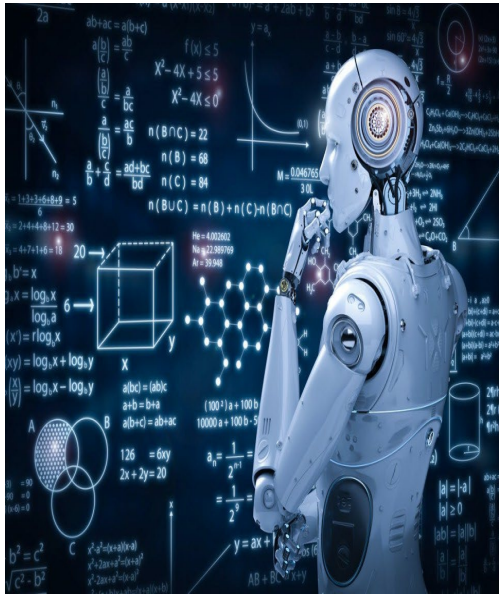
- Less Logic
- More Intuition

→ More Logic, Less Intuition

The future







- Less Logic
- More Intuition

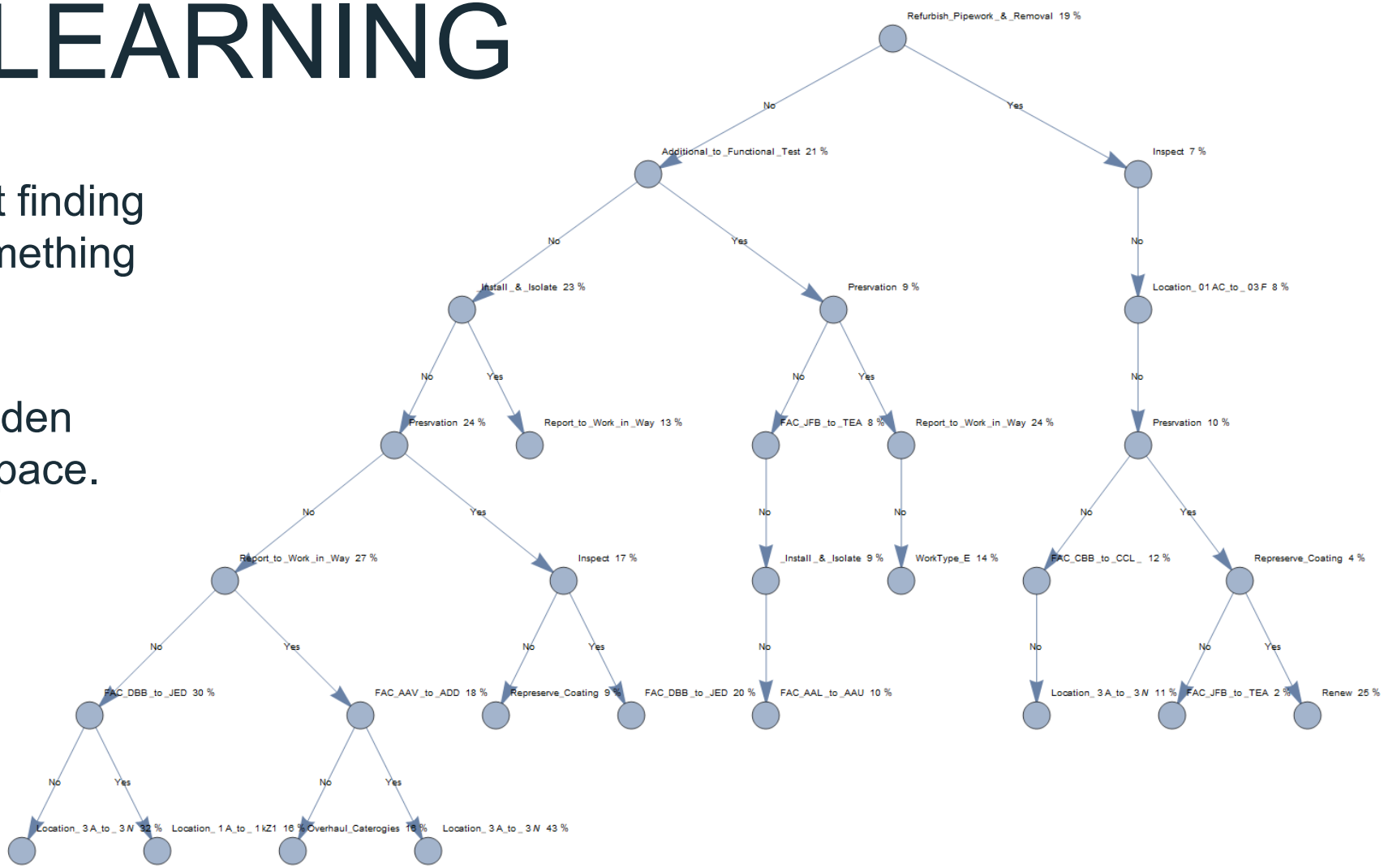
More Logic
Less Intuition

More AI

MACHINE LEARNING

Machine learning is good at finding non-linear relationships something that humans struggle with.

It is also good at finding hidden patterns in n-dimensional space.

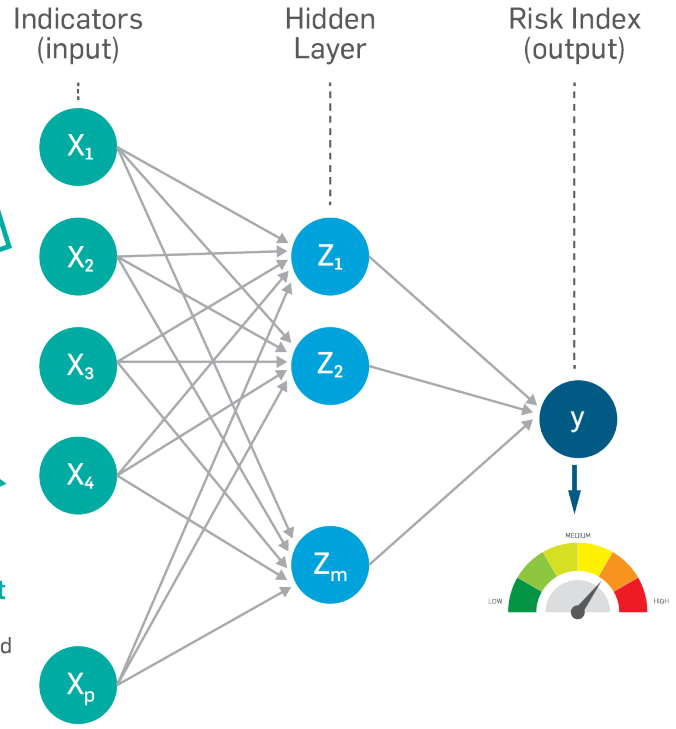


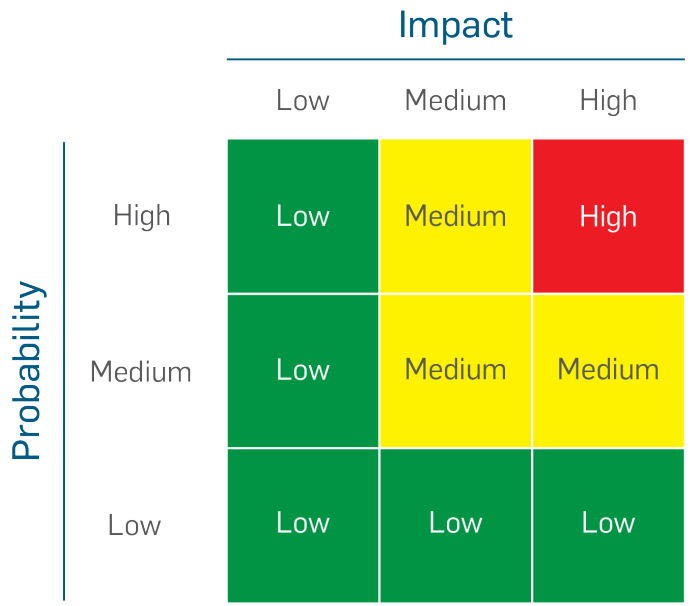
AtkinsRéalis – Commercial in Confidence

USING MACHINE LEARNING TO PREDICT RISKS

Training
The model trains on past indicators from normal operations and accidents. Relevant experts may assis the training phase.

Risk assessment
The instantaneous plant state is provided to the model through indicators and analysed by each layer to assess the related risk.



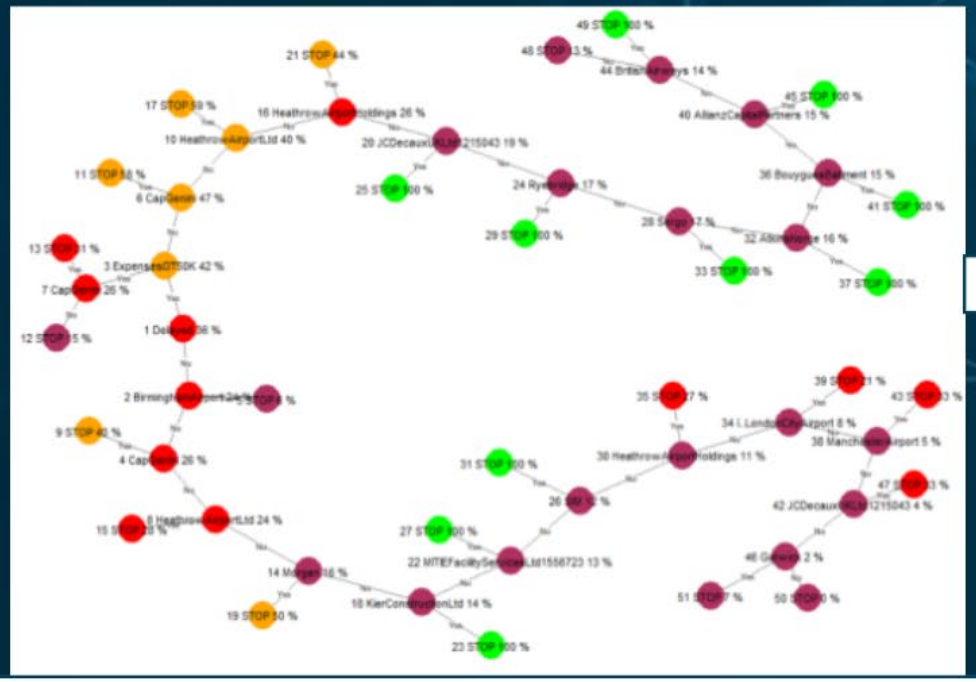


```
# define Workflow
class TaskGetData(d6tflow.tasks.TaskPqPandas):  # save dataframe as parquet

    def run(self):
        iris = sklearn.datasets.load_iris()
        df_train = pd.DataFrame(iris.data,columns=['feature{}'.format(i) for i in range(4)])
        df_train['y'] = iris.target
        self.save(df_train) # quickly save dataframe

class TaskPreprocess(d6tflow.tasks.TaskCachePandas):  # save data to memory
    do_preprocess = luigi.BoolParameter(default=True) # parameter for preprocessing yes/no

    def requires(self):
        return TaskGetData() # define dependency
```



Project Health Indicator Machine Learning Post Processor

Objective: What is the Risk of an increasing unbilled value over the course of a number of months?

To use the tool answer "Yes" or "No" to the following questions.

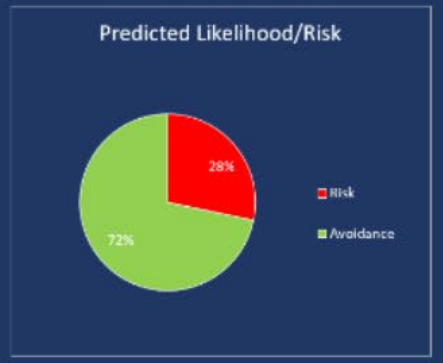
Question:

Is this an Air Project?

Yes | No

Predicted Risk	28%
Predicted Avoidance	72%
RAG status	

Reset



Question

Suppose you're on a game show, and you're given the choice of three doors:

Behind one door is a car; behind the others, goats.

You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat behind it.

He then says to you, "Do you want to pick door No. 2?"

Is it to your advantage to switch your choice?

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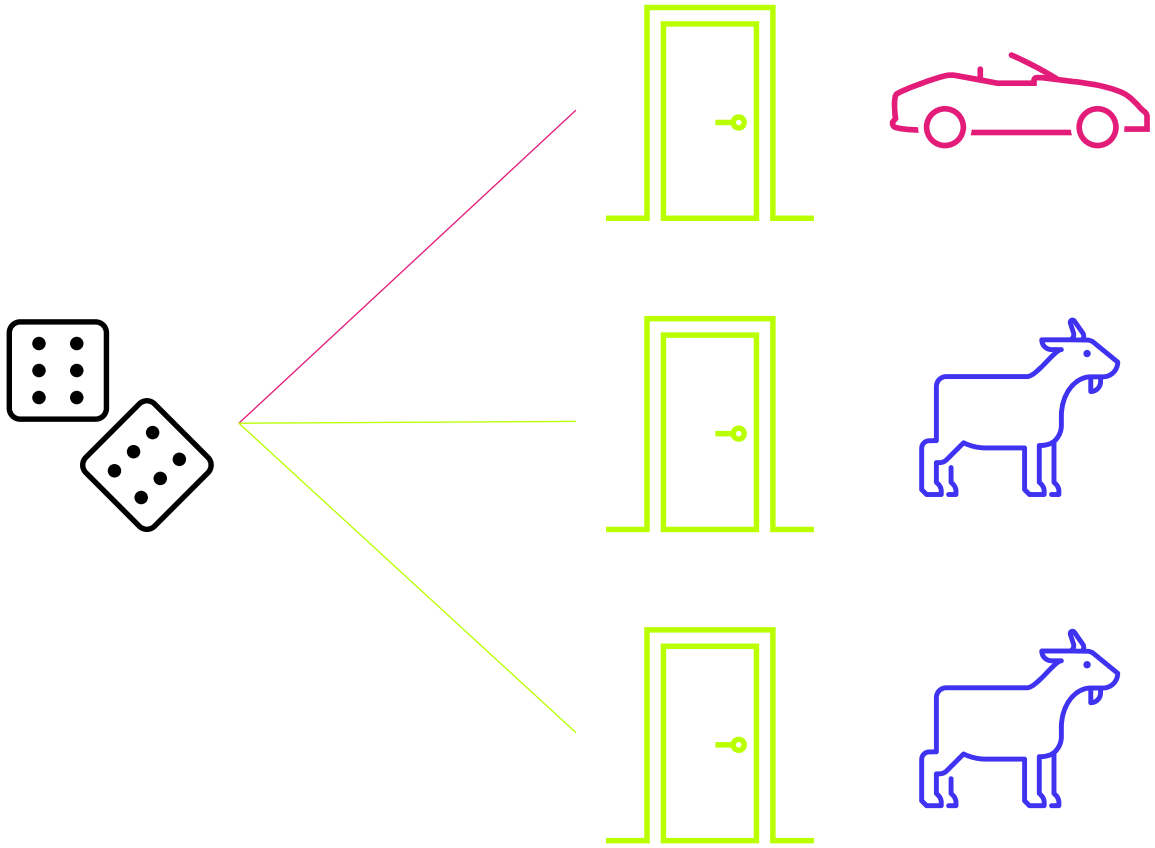

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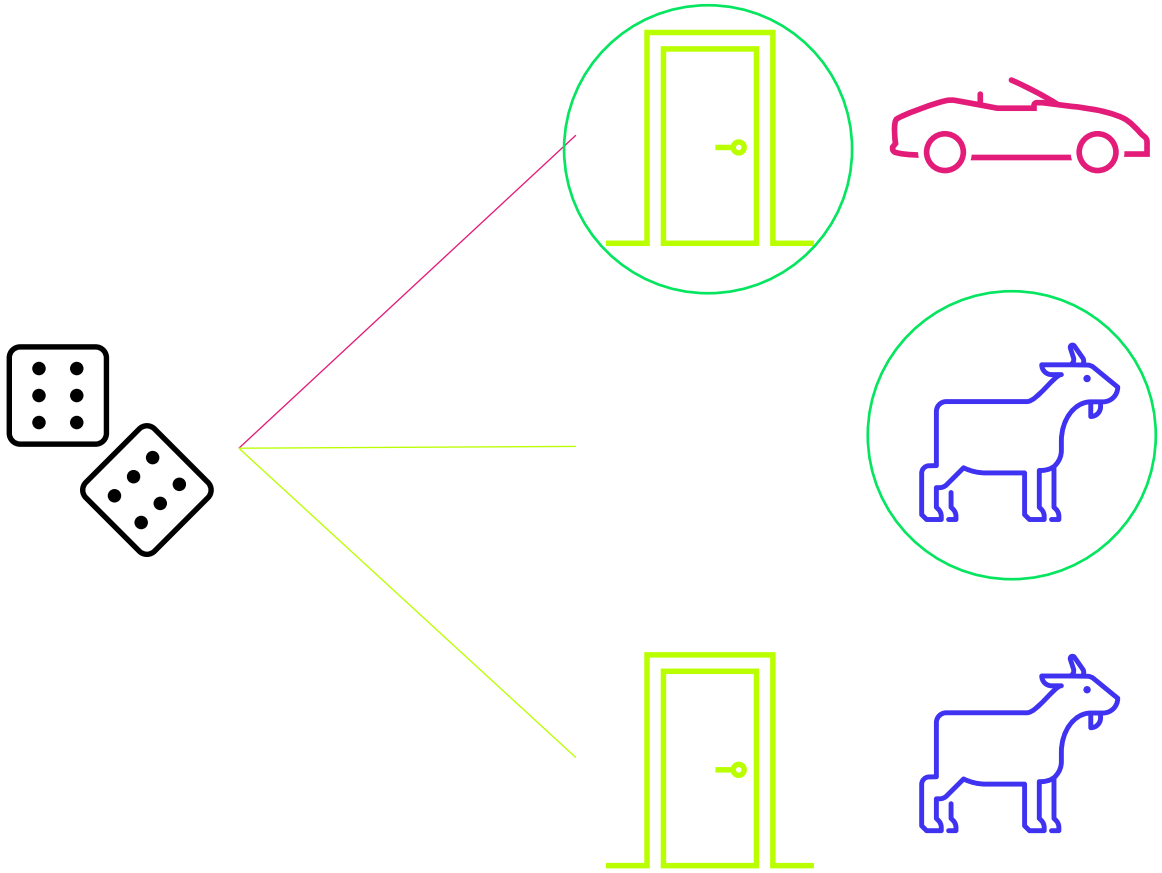
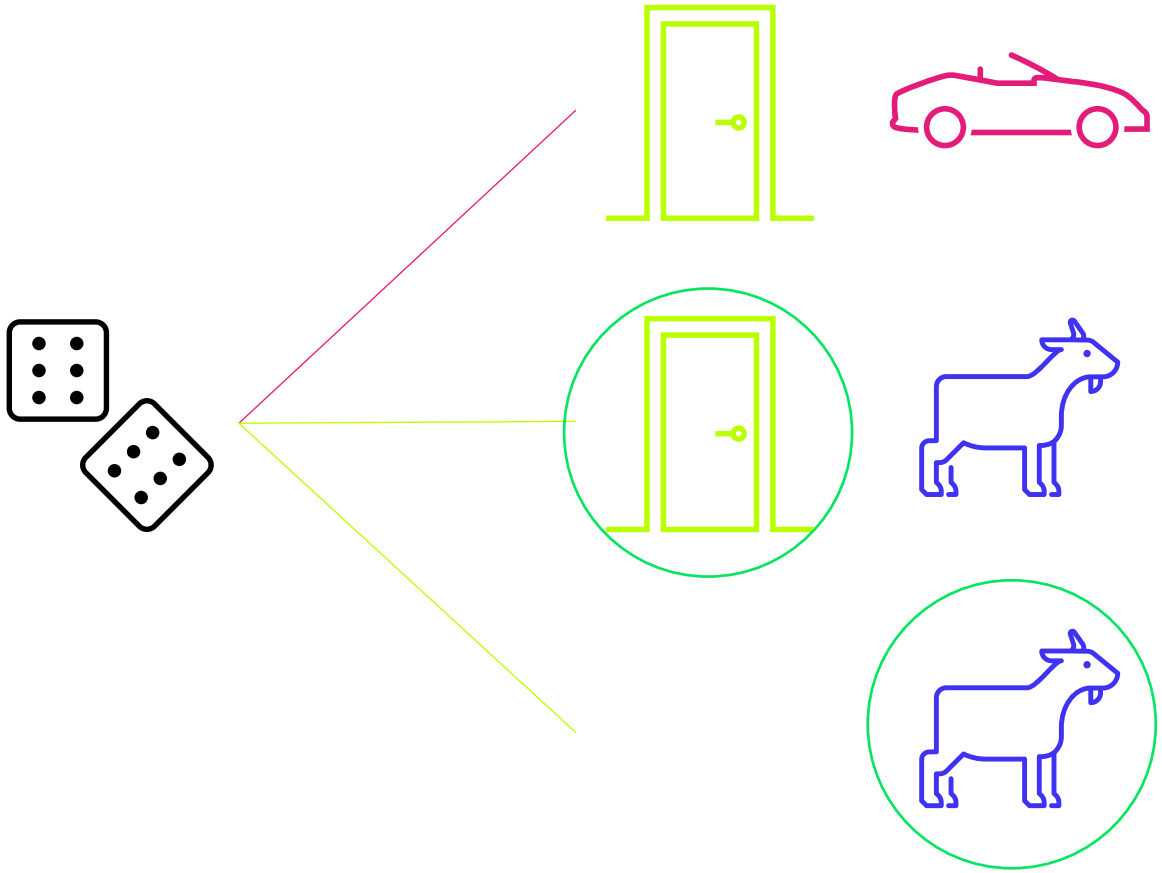


Do you want to Swap Doors?

Here comes the maths



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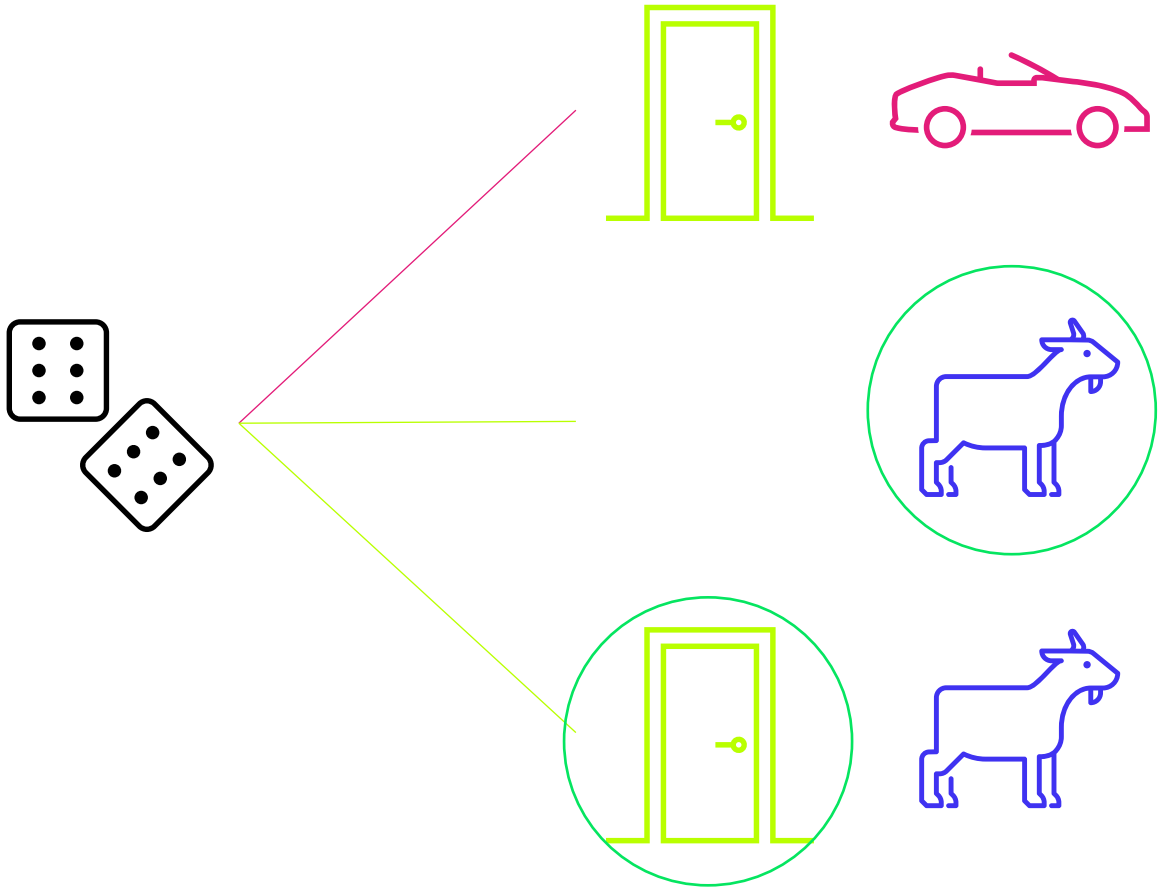
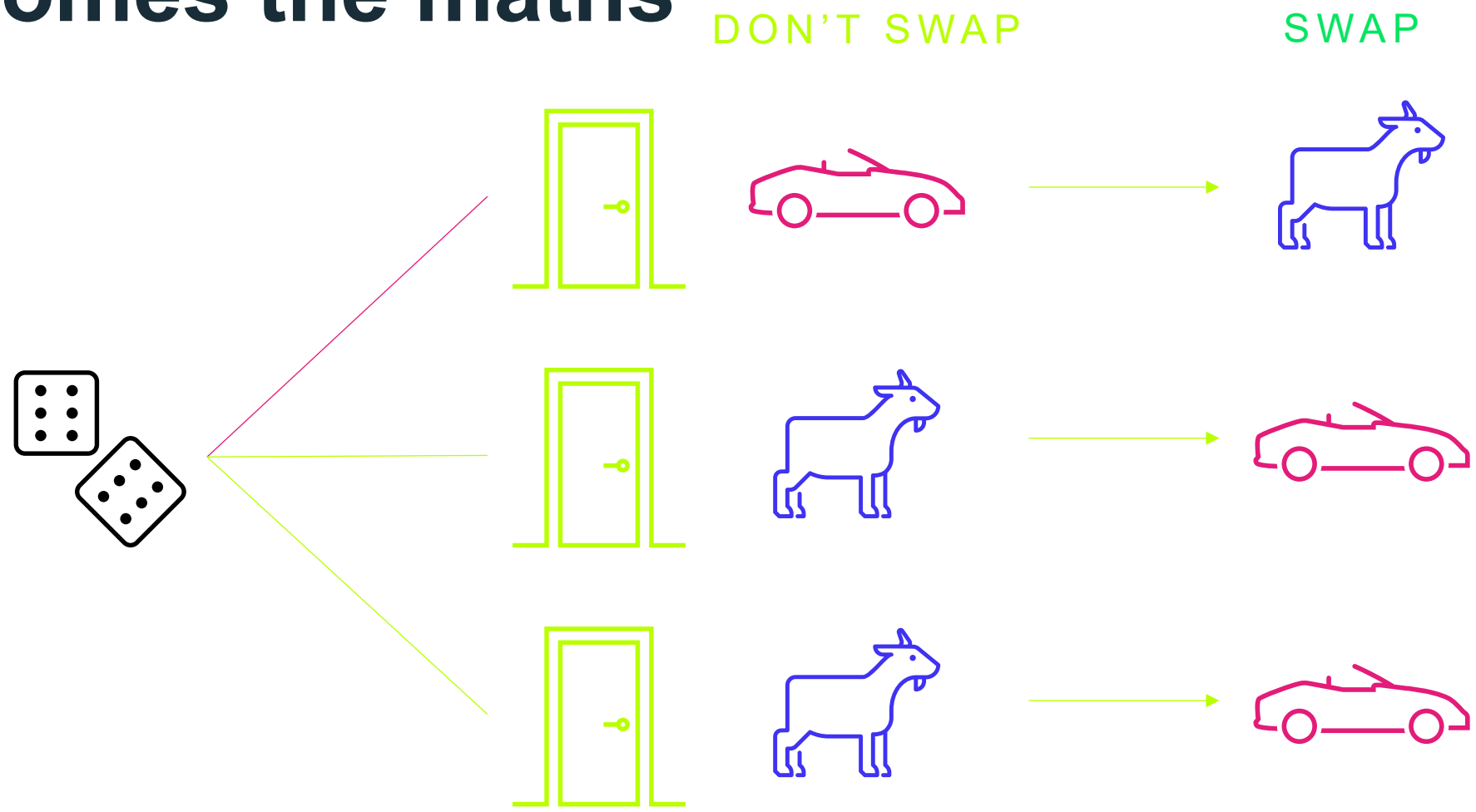
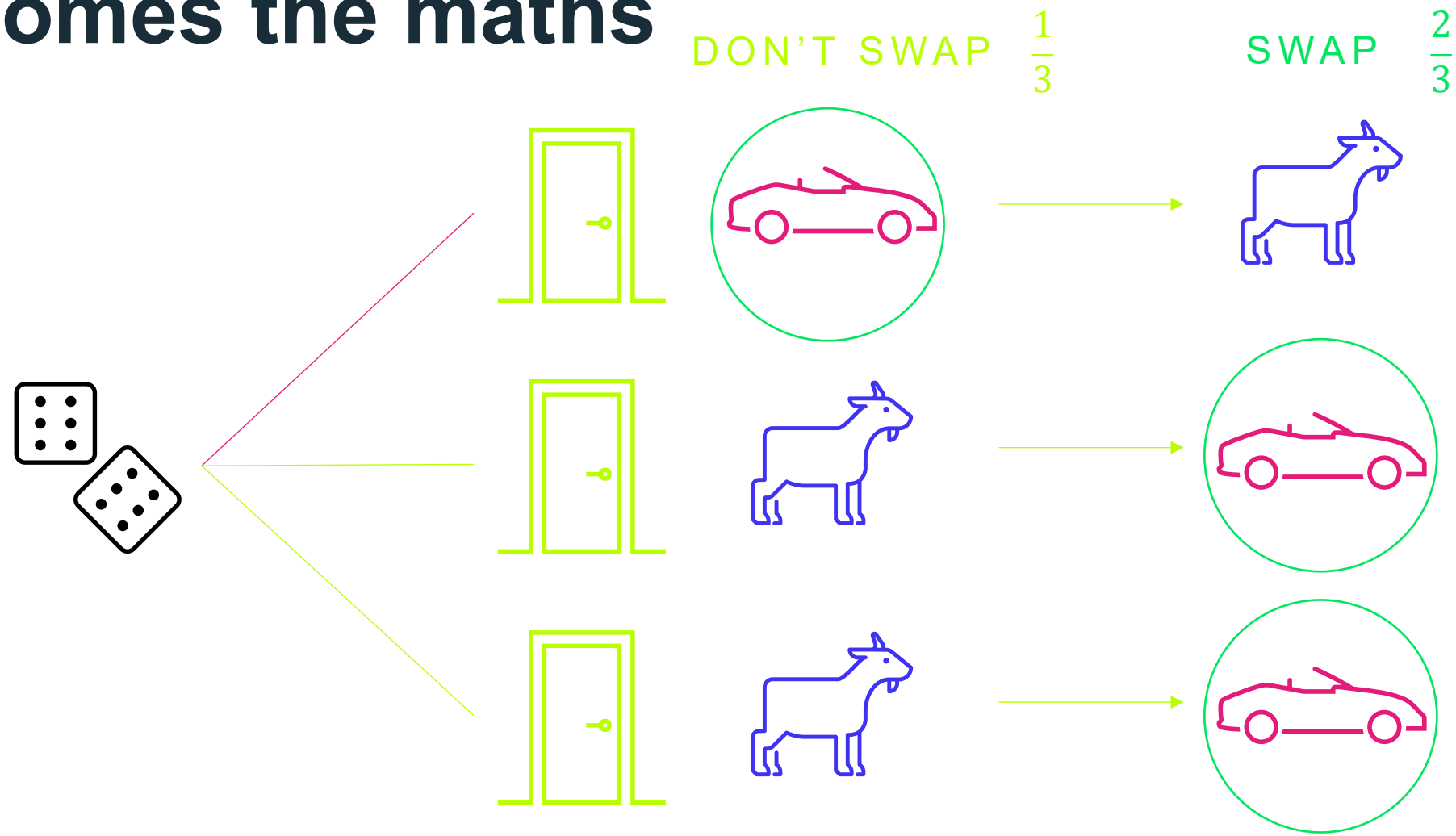


Do you want to Swap Doors?

Here comes the maths



Here comes the maths



In summary

- The role of a cost model is to enable a successful project outcome.

- Risk and probability has an important part to play in this.

In conclusion

- Risk and its underlying probability in cost modelling should be logical not purely intuitive
- Soon, if not already, this will employ more AI approaches.
- To neglect this is to potentially compromise our cost modelling solution that enables a successful project outcome.
- This is the Art of Decision Making.

thank you

AtkinsRéalis