DNV·GL

OIL & GAS

Quantitative Risk Based Inspection

Keeping it Simple

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Apologies in advance

Quantitative

Qualitative

Introduction

This is the story of our development of a purely quantitative Risk Based Inspection methodology with one simple goal:

To allow engineers to make clear, consistent and holistic decisions based on their judgement and experience.

We won’t be presenting the system itself – just talking about the problems we faced and how we solved some of the key challenges.

Introduction

I am a structural engineer, so this is based on developing a qualitative Risk Based Inspection Methodology for structural components.

However, the lessons learned are valid for any type of component that you are assessing on a purely qualitative basis.

What is Risk Based Inspection?

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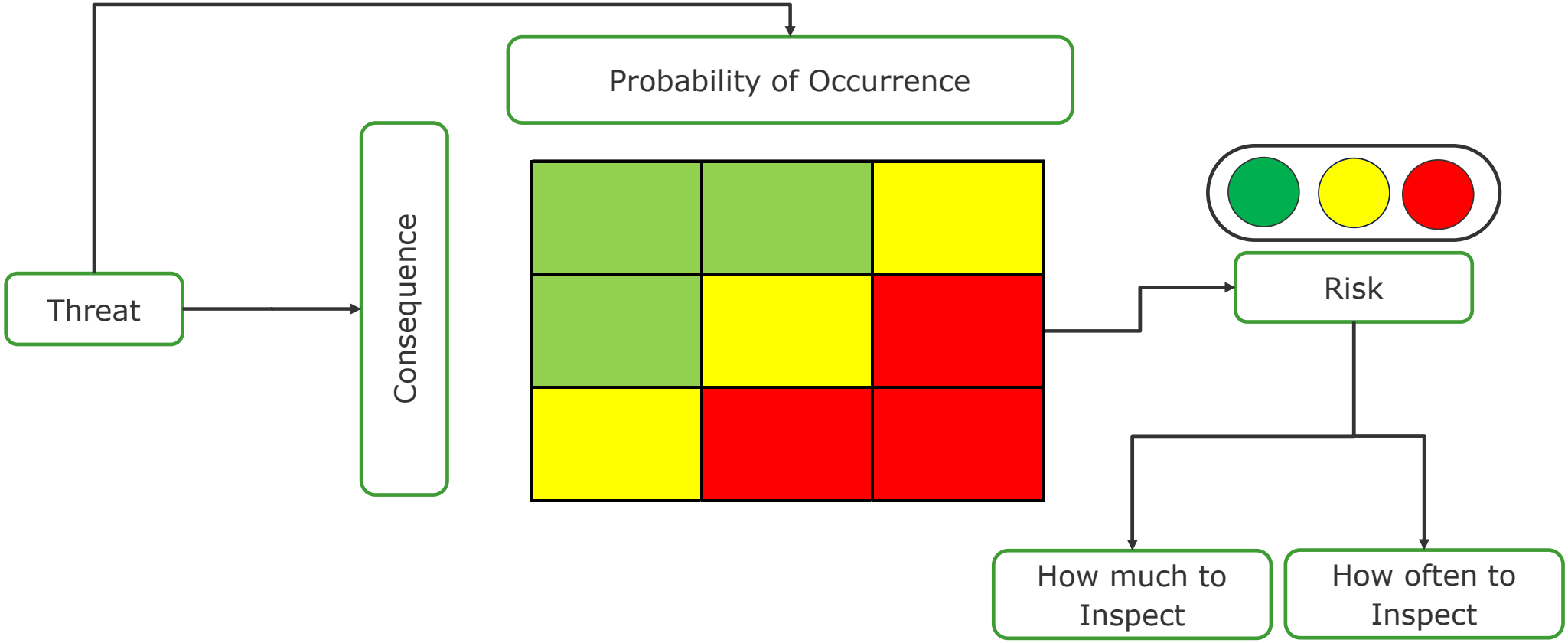
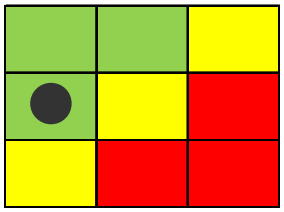
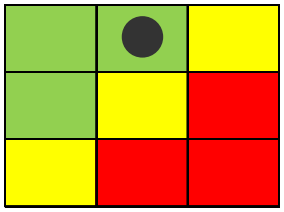
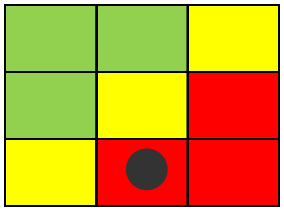
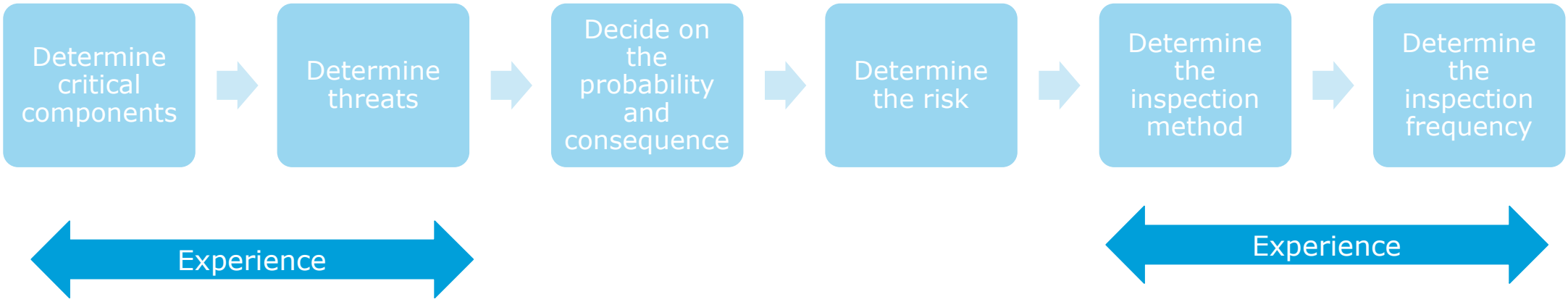


Some Examples

Probability	Consequence	Risk	
Fatigue on structural steel due to rotating equipment LOW	Limited structural failure MEDIUM	LOW	
Limited overload of tertiary steel MEDIUM	Limited damages to one or two members LOW	LOW	
Crane pedestal fatigue MEDIUM	Failure of crane pedestal HIGH	HIGH	

How do you do RBI?



Quantitative or Qualitative

Quantitative

Using Numbers

"Relating to, measuring, or measured by the quantity of something rather than its quality."

Qualitative

Using Words

"Describing the quality of something in size, appearance, value, etc. Such adjectives can be sub-modified by words such as *very* and have comparative and superlative forms."

Systems vs Judgement

The "Semi–Quantitative" – The appearance of science

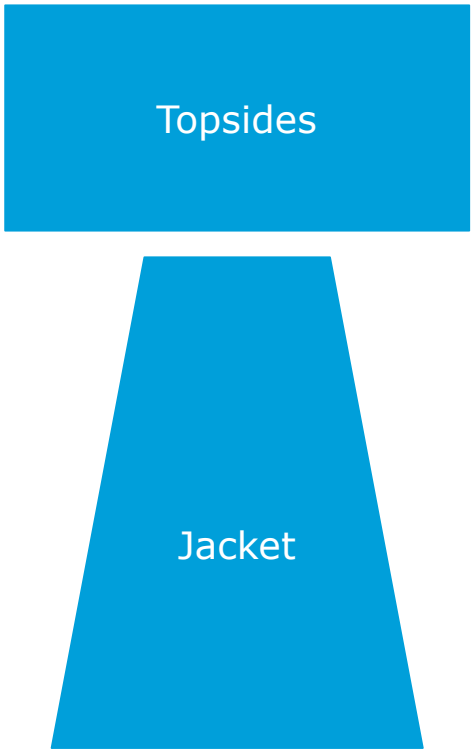
$$P = f_1 \, x \, f_2 \, x \, f_3 \, x \, f_4 \, x \, f_5$$

$$C = f_6 \, x \, f_7 \, x \, f_8 \, x \, f_9 \, x \, f_{10}$$

Condition	Value
Condition 1	1
Condition 2	3
Condition 3	5
Condition 4	10
Condition 5	20

Surprisingly regular and rounded numbers

Fully Qualitative



For use when no quantitative data is available

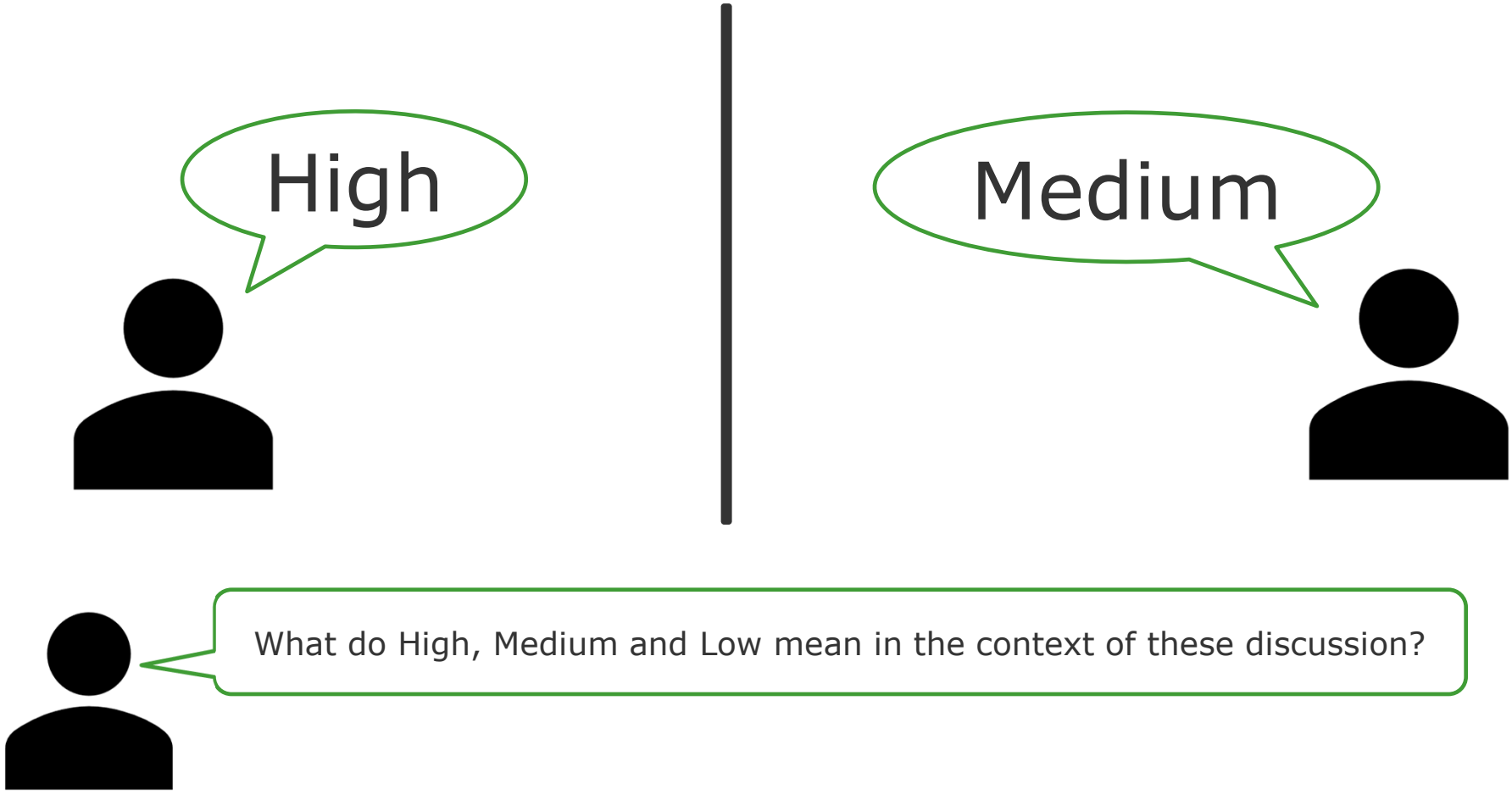
No black boxes

Experience matters

Framework for decision making

The first iteration

Independent Agreement

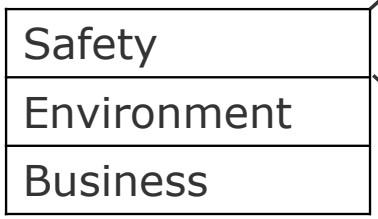


Probability Considerations

Inspection History
Industry Experience
Historical Repairs
Loading / Operational Changes
Analysis
Design

Consideration	Probability		
	High	Medium	Low
Inspection History	No or limited history	Incomplete history	Extensive history
	No plan in place or plan has not been followed	Partial completion in accordance with the inspection plan	Completed in accordance with the inspection plan
	Significant anomalies affecting SCE's	Significant anomalies affecting non-SCE's or minor anomalies affecting SCE's	Minor anomalies affecting non-SCE components only.

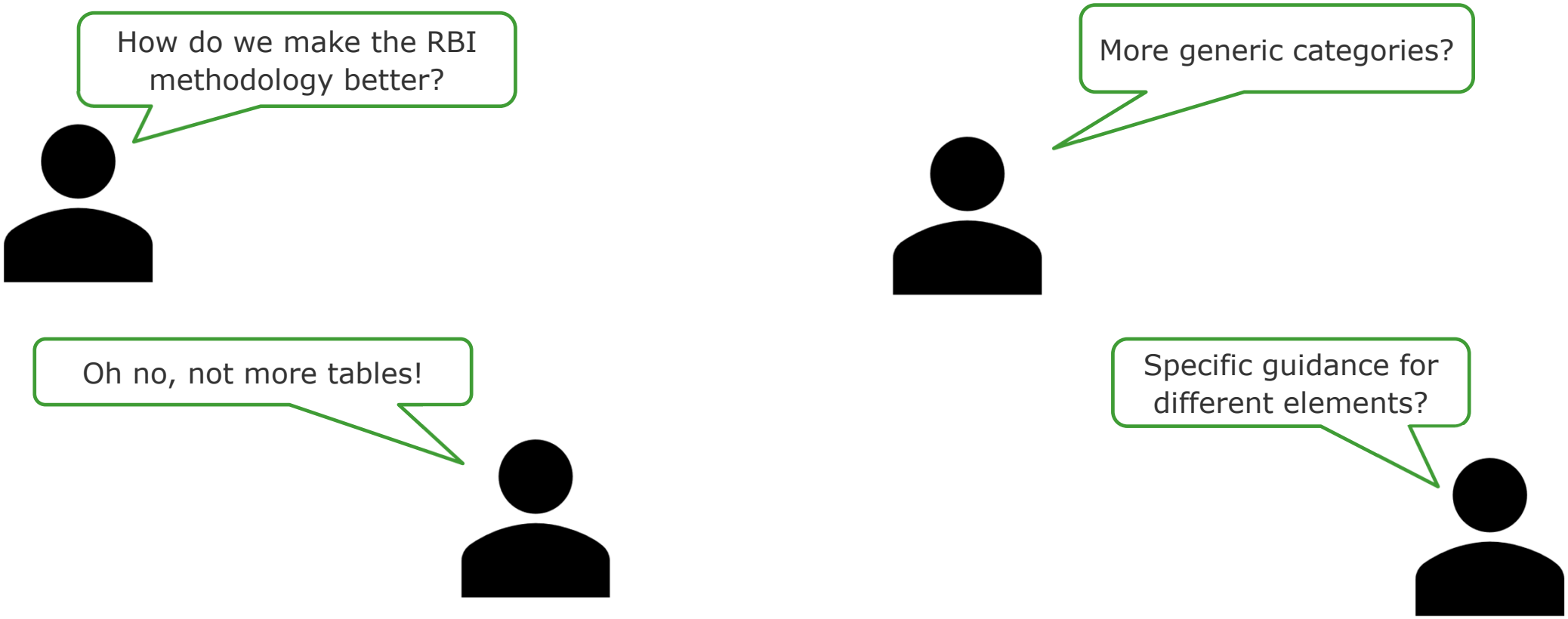
Consequence Considerations



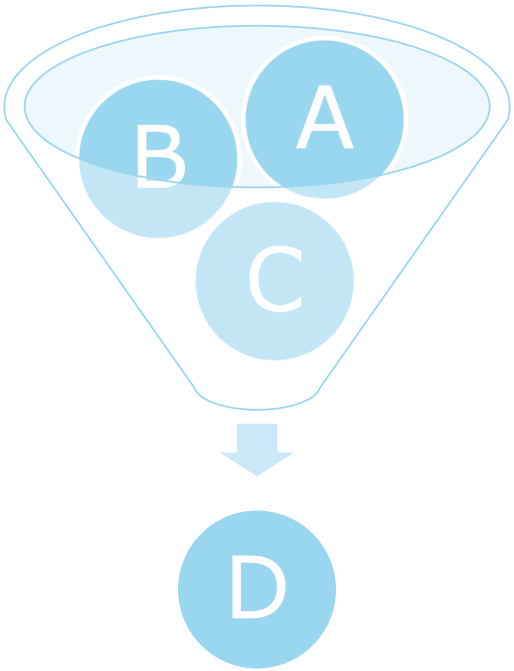
Consideration	Consequence		
	High	Medium	Low
Safety	Fatality	Moderate to Major Injury	Minor Injury
	Complete failure of SCE	Impairment of SCE though it remains functional	No impact on SCE

So, that's the end of it, right?

So how do we fix it?



Holistic

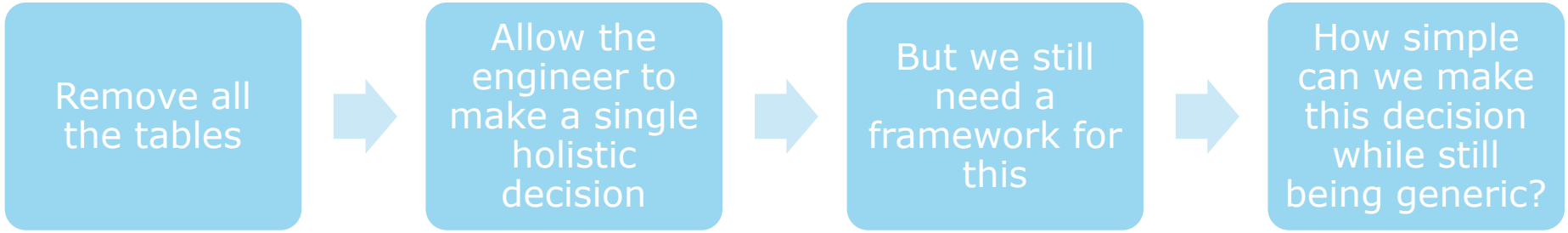


Characterized by the belief that the parts of something are intimately interconnected and explicable only by reference to the whole.

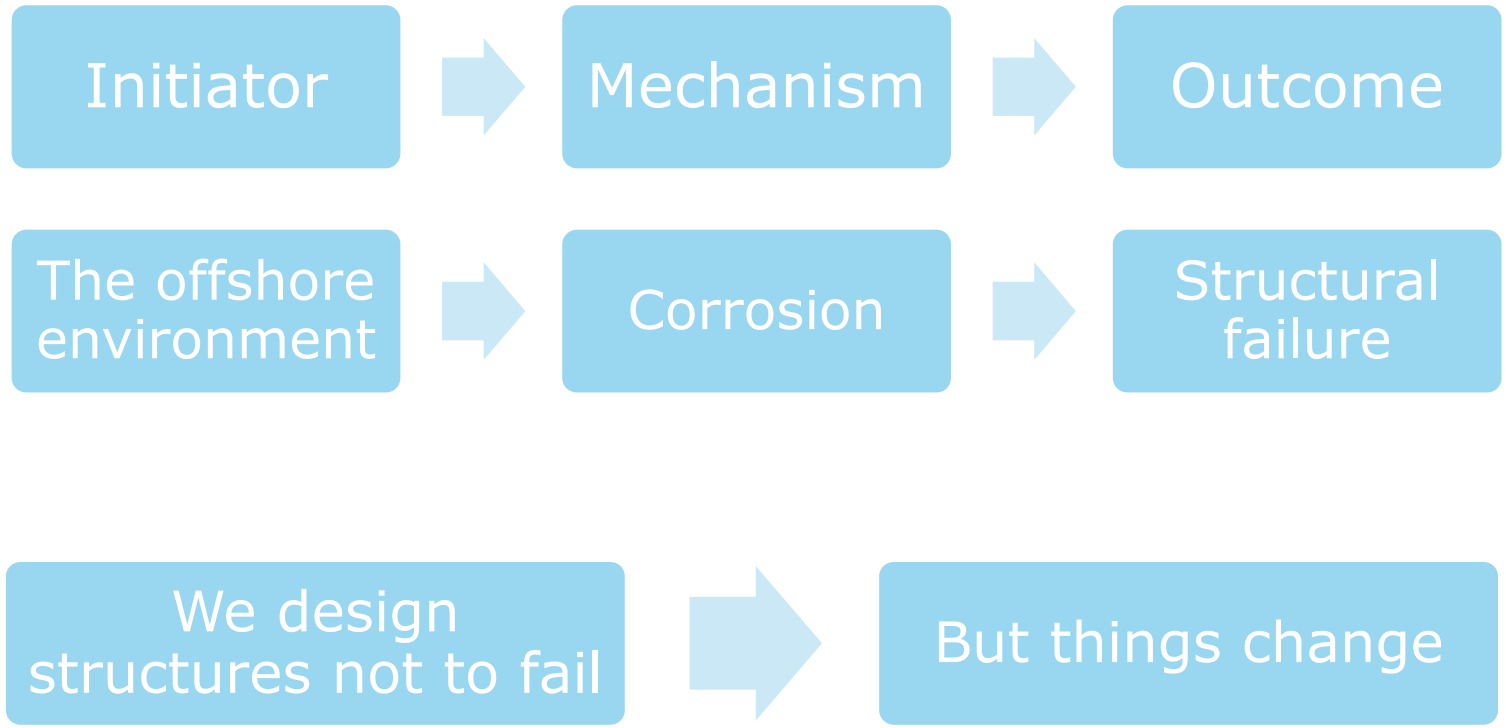
The second iteration

Problem 1 : How to improve the system

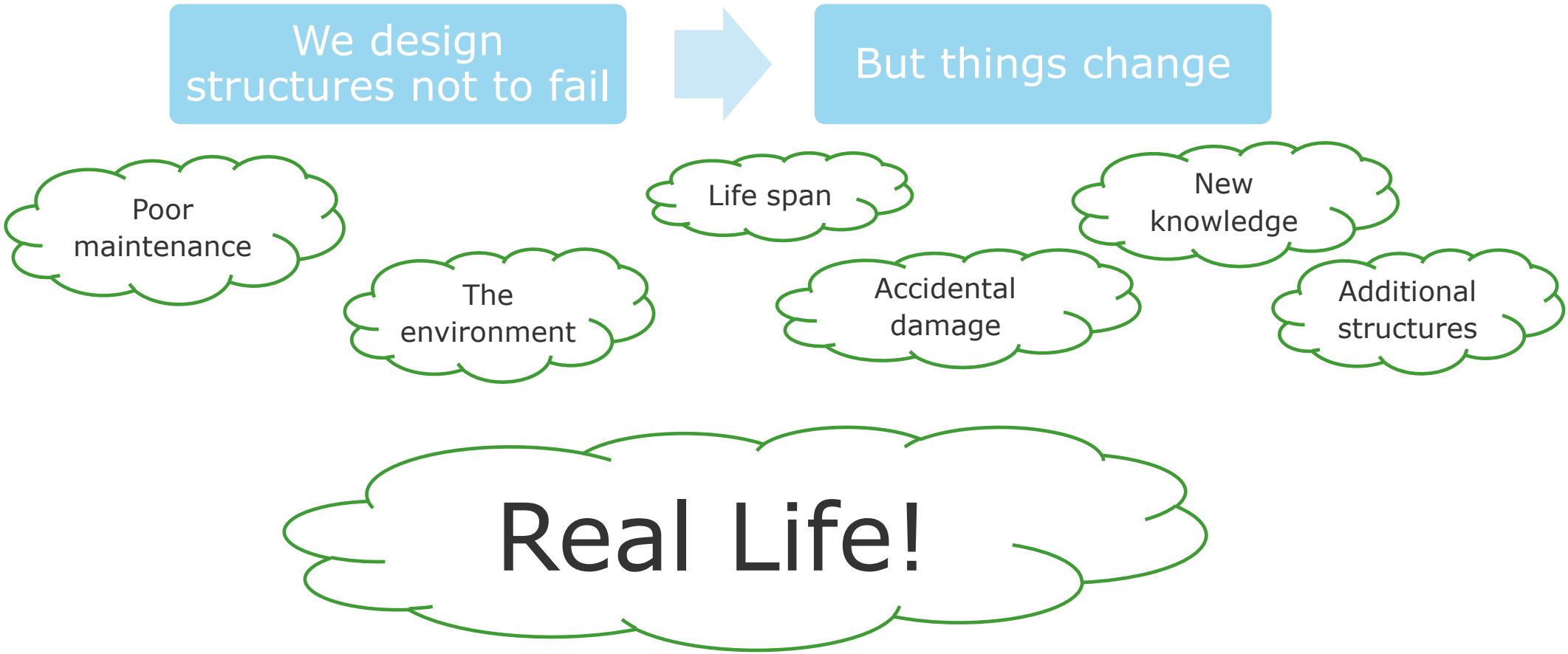
Making probability decisions



Why do things fail?



What changes?



Four Questions

- Is the initiator likely to occur?
- Did we know about the mechanism when the component was designed?
- Are the original design conditions still valid?
- Are any new mitigations as effective as if they were originally designed in

Example – Corrosion of Topsides Secondary and Tertiary Steel

Is the initiator likely to occur?	Did we know about it when the component was designed?	Are the original design conditions still valid?	Are any new mitigations as effective as if they were originally designed in
• Yes • Corrosion is caused by the offshore environmental conditions	• Yes • Corrosion is a well know phenomenon and will have been mitigated against by using an appropriate paint specification	• No • Poor maintenance • Longer than predicted life	• No • Poor maintenance

Corrosion of topsides secondary and tertiary steel has a high probability of occurring

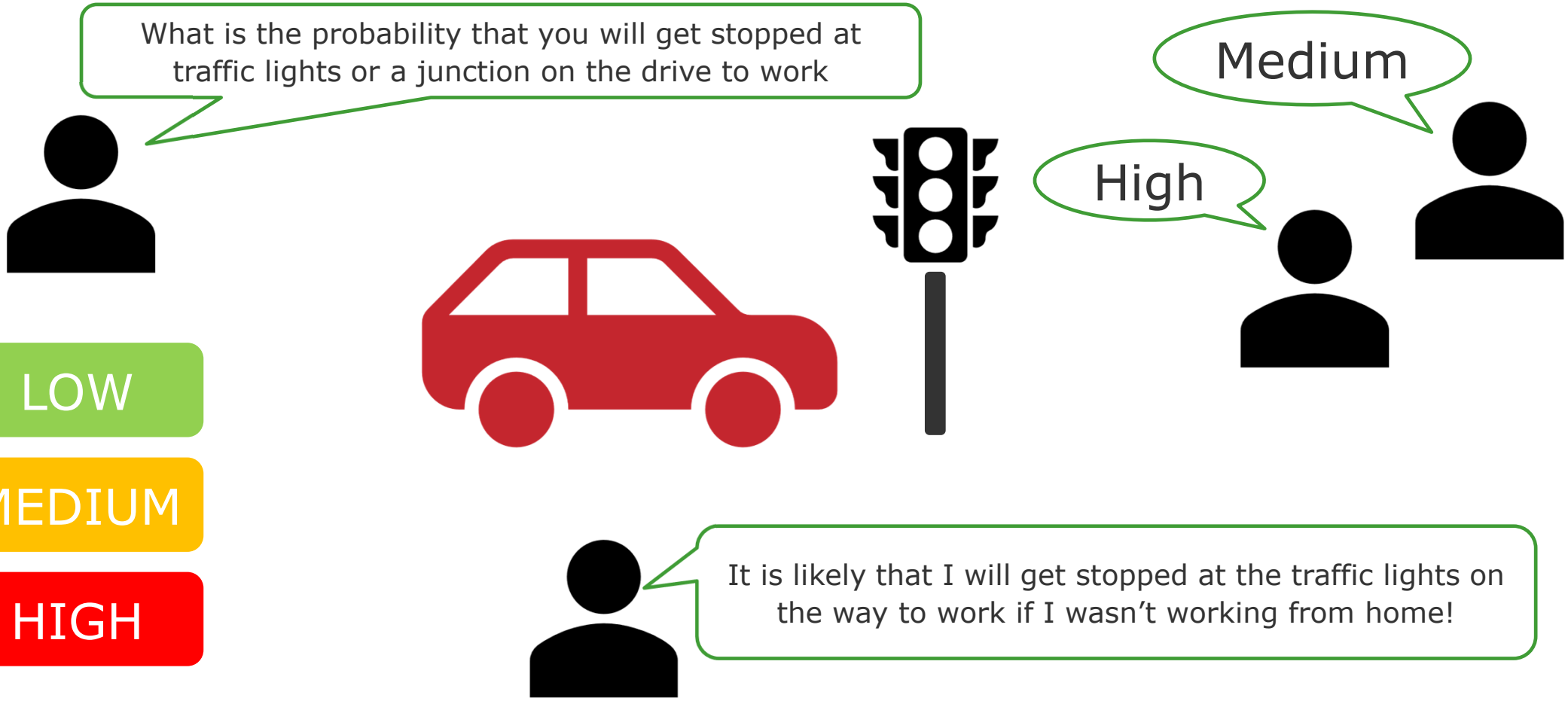
Example – Overload of Primary Steelwork

Is the initiator likely to occur?	Did we know about it when the component was designed?	Are the original design conditions still valid?	Are any new mitigations as effective as if they were originally designed in
• Yes • Bigger than anticipated loads can occur	• Yes • Factors of safety are built into both the component strength and the projected loads	• Yes • Primary steel is well maintained and loads limits are reasonable	• Not applicable

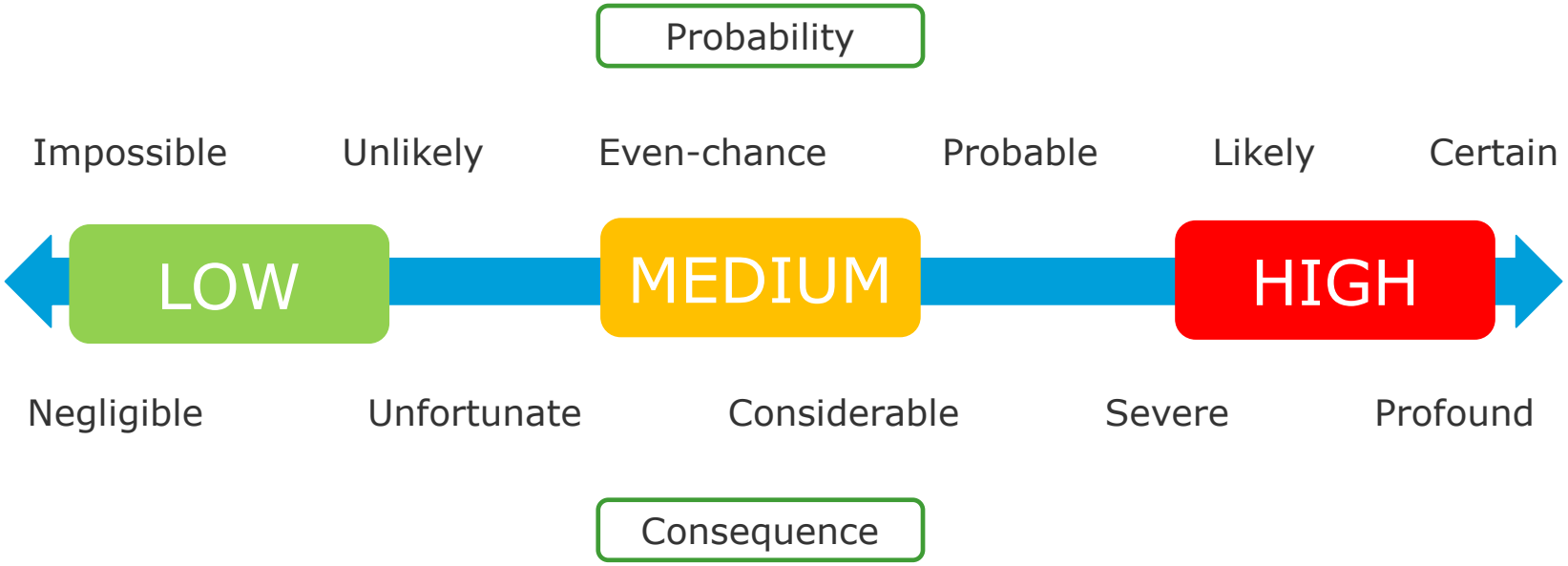
Overload of primary steelwork has a low probability of occurring

Problem 2 : The meaning of words

Words

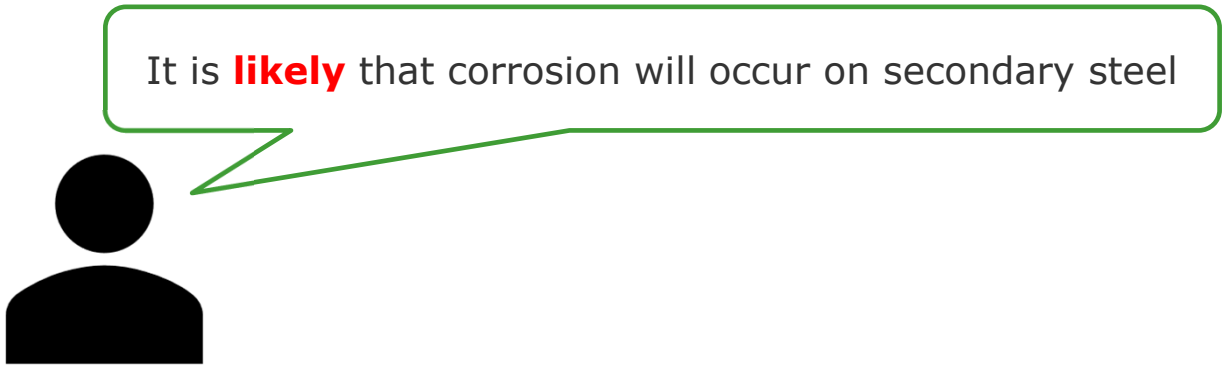

What is the probability that you will get stopped at traffic lights or a junction on the drive to work
Medium
High
LOW
MEDIUM
HIGH
It is likely that I will get stopped at the traffic lights on the way to work if I wasn't working from home!

Words


Probability
Impossible
Unlikely
Even-chance
Probable
Likely
Certain
LOW
MEDIUM
HIGH
Negligible
Unfortunate
Considerable
Severe
Profound
Consequence

Terminology

Natural Language	Description	Real Word Example
Likely	Something that appears almost certain to occur.	When driving a car on a commuter journey it is likely to get stopped at a red light or junction.



The problems with the real world examples

Consequence

Personal vs Business

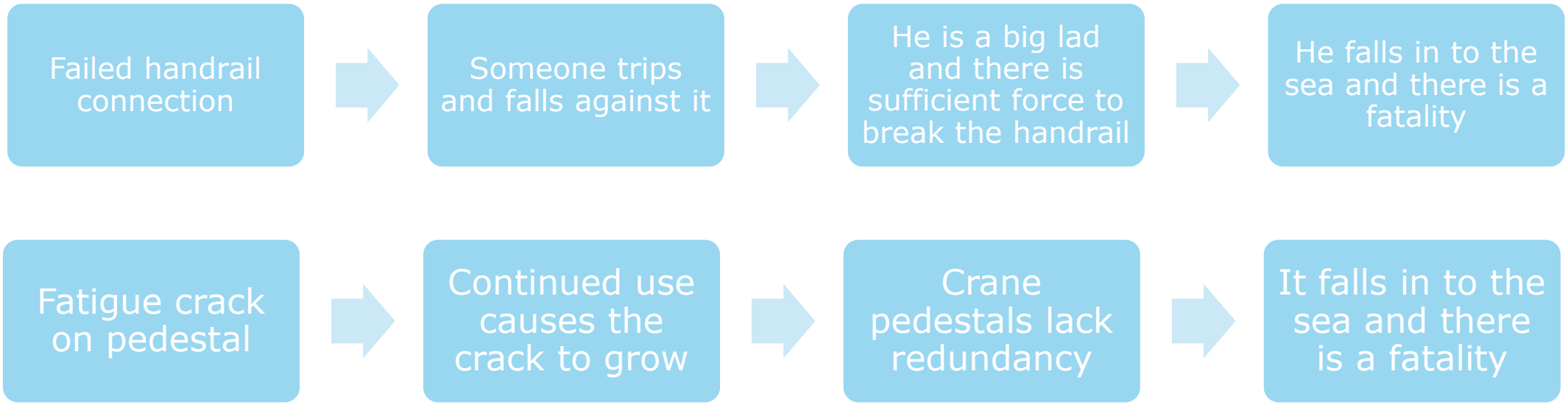
Running a red light in my car could have severe consequences for me

Loss of a primary brace would have severe consequences for the structural integrity of the platform

Consequence requires context in a way that probability does not

Problem 3 : Consequence Escalation

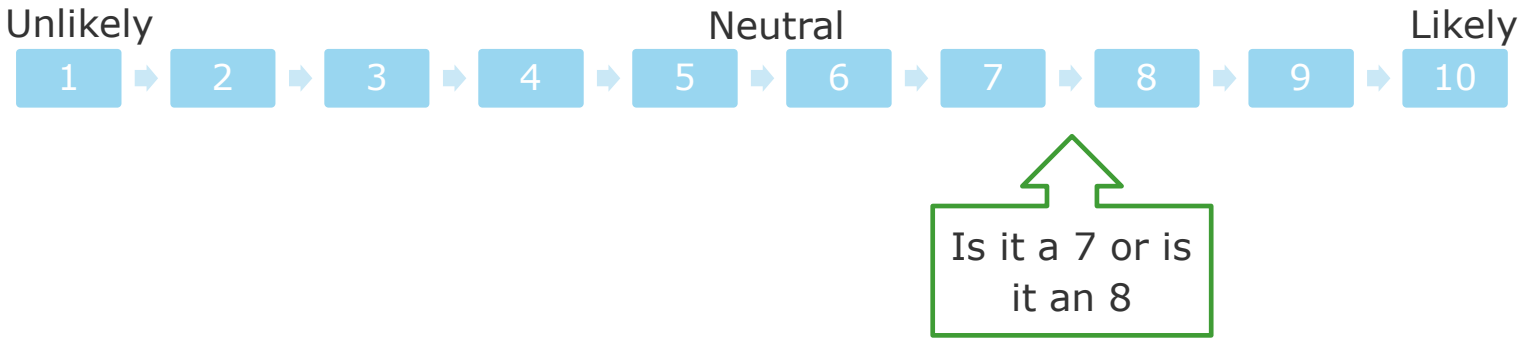
Consequence Escalation



Problem 4 : My matrix is bigger than yours

Risk Matrix Size

How likely are you to recommend Super-Duper kitchen cleaner to your friends?



Overchoice

(choice overload)

A cognitive impairment in which people have a difficult time making a decision when faced with many options.

Risk Matrix Size

Corporate risk matrices are typically at least 5x5, sometimes more.

It is difficult to get consistent decision making on anything more than three levels.

Risk Matrix Alignment

Probability	Consequence 1	2	3	4	5
5	2	2	3	4	4
4	1	2	3	3	4
3	1	2	2	3	3
2	1	1	2	2	3
1	1	1	1	1	2

Customer risk levels 1 to 4 aligned to High/Medium/Low by comparing descriptions of risk

Probability			Consequence: Low 1	Medium 2	Medium 3	High 4	High 5
High		5	Medium	Medium	High	High	High
		4	Low	Medium	High	High	High
Medium		3	Low	Medium	Medium	High	High
		2	Low	Low	Medium	Medium	Medium
Low		1	Low	Low	Low	Low	Medium

70% of the decisions give the same outcome

Probability			Consequence: Low 1	Medium 2	Medium 3	High 4	High 5
High		5	Medium	High	High	High	High
		4					
Medium		3	Low	Medium	Medium	High	High
		2					
Low		1	Low	Low	Low	Medium	Medium

Probability and Consequence levels 1 to 5 aligned to High/Medium/Low as a best fit on the matrix

The Golden Rule

The engineer is always right

In Summary

Why use purely qualitative methods?

No quantitative methods

Avoid the appearance of science

Engineering experience

How to keep it simple

Holistic decisions

Framework for decision making

Baselines for terminology

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