International Council on Systems Engineering
A better world through a systems approach

Into the Unknown

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How to make a good decision

AP

Imagine you are driving to the airport to catch a flight.

1. Most-Likely time is 2 hours
2. Most-Likely time is 2 hours with a worst case 2.5 hours
3. Most-Likely time is 2 hours with a worst case of 10 hours

There may be a risk if we are in an uncertain environment and we make decisions on only a Most-Likely Estimate. A good decision should also include the Plausible Worst-Case scenario.

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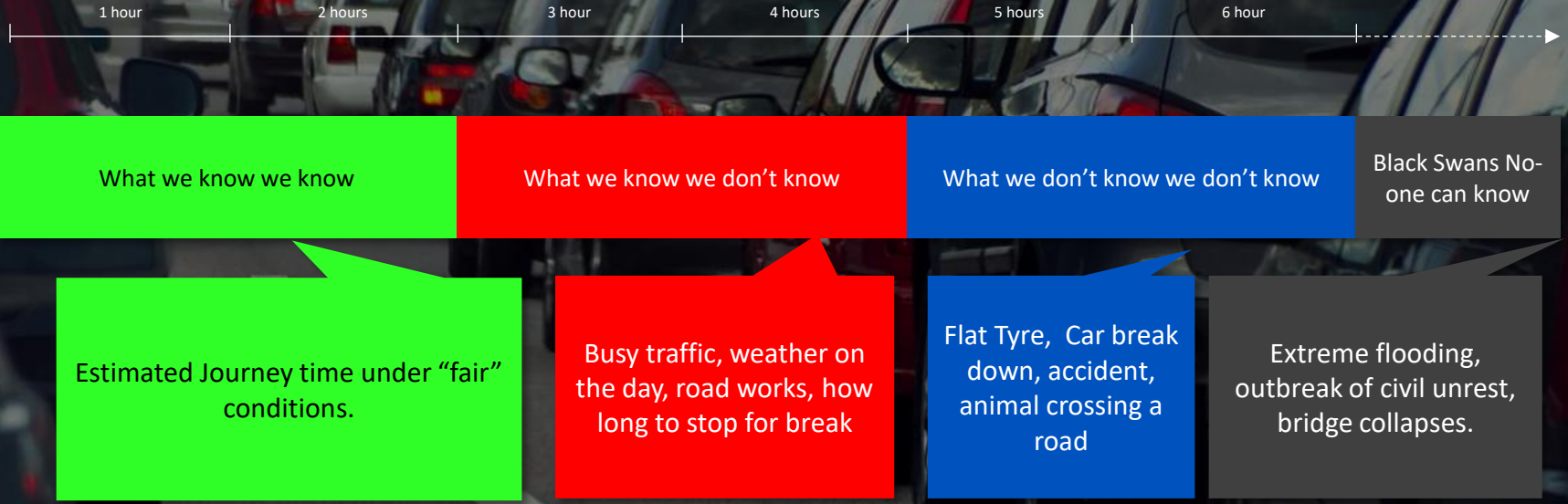
Planning an important car journey

The more critical the journey, the more “Protection” you might want to consider. Or find ways to reduce the unknowns e.g. travel in the night when the roads are quieter. Or go by train.



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Exercise

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Assumptions about a cup of tea

If you were to make “tea for two” what assumptions might you make e.g. I have tea, I have cups……

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1. Assume we both want tea
2. Assume tea is for 2
3. Assun
4. Assun
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11. Assun
12. Assun
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15. Assun
16. Assun
    water
17. Assume I have access to water
18. Assume water is safe to use
19. Assume I have a kettle
20. Assume the kettle is working
21. Assume I have power
22. Assume I have heated enough water
23. Assume the water will be hot enough

d
v"
spose of the used teabag

ed
first

nt) sugar
with the tea
a to them!
39. Assume I have enough time to drink it
40. Assume I will not get paid for this!
41. Do you want iced tea?

1. What could be simpler than a cup of tea yet there were so many assumptions we make. Chances are a complex project could have many hundreds of assumptions
2. We did not detect them all. Chances are, for your projects you will not had detected all your assumptions. This might be a source of issues later

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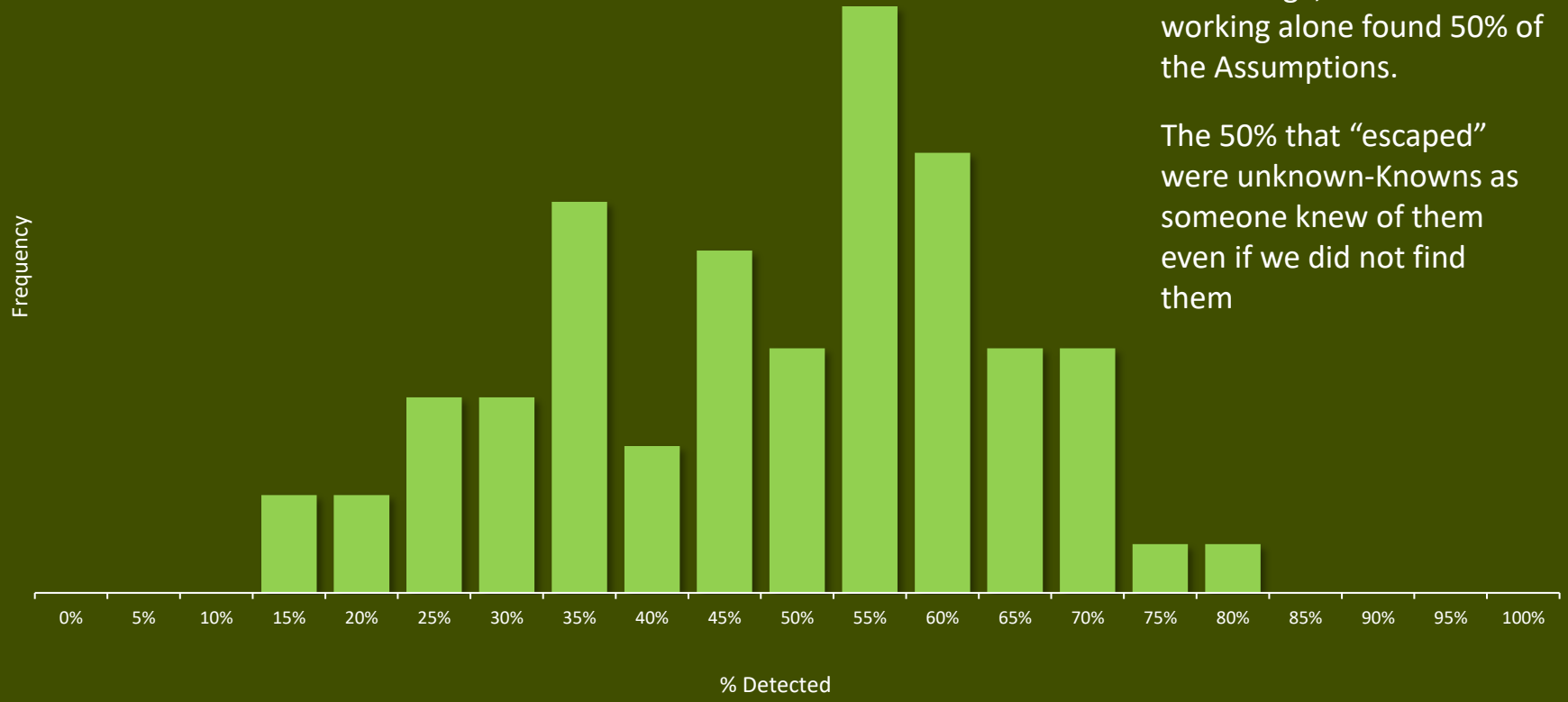
How Many Assumptions Did We Find?



On average, someone working alone found 50% of the Assumptions.

The 50% that “escaped” were unknown-Knowns as someone knew of them even if we did not find them

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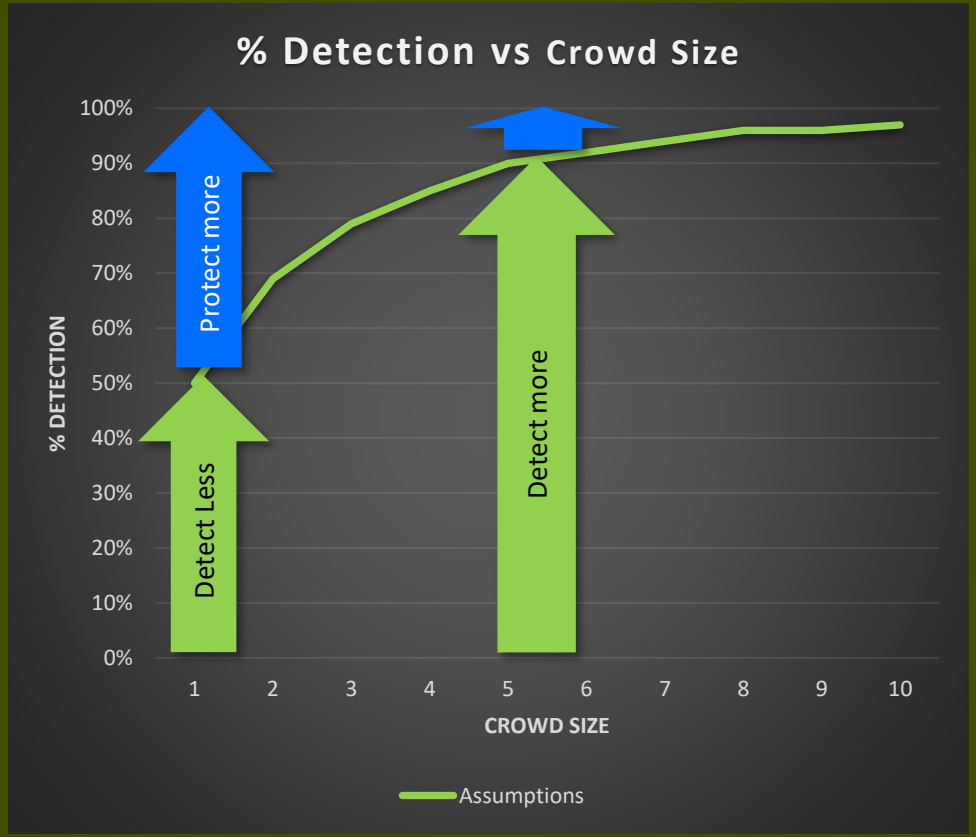
How many Systems Engineers does it take to change a light bulb?

This chart shows the success rate of Assumption Identification based on Crowd Size. Because everyone has different experiences, as we add more people to the group, they tended to find more of the Assumptions. As can be expected, the benefit begins to diminish for larger groups.

Even with 10 people, they did not find 100% of the Assumptions. There will always be "escapes". We need to protect ourselves from what we have not considered



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Risks with a Car Journey

What are some of the risks and uncertainties when estimating the duration of a car journey e.g. busy traffic, road closures, bad weather …..

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1. Takes longer than expected to load the car (luggage and kids)
2. Can't get the luggage in the car and spend time re-packing
3. Slow at leaving your house (
etc)
4. Need to defrost the car
5. Car won't start
6. Need to go back for someth
something off etc)
7. Poor Traffic (Friday rush "ho
8. Poor Weather
9. Slow driver on country lane
10. Animals loose on road (e.g.,
11. Flat tyre
12. Breakdown (other) – you
13. Breakdown – another perso
14. Accident – you
15. Accident – another person
16. Skid off road due to ice
17. Public events (fun run, cycle race, riots, protestors etc)
18. Poor Navigation (GPS / Partner) and getting lost
19. Diversions / Road closure
20. Bridge closure or blocked
21. Other Detours (by you)
22. Traffic light failure causes congestion
23. Traffic lights against you
24. Speed of the road changed (speed zones)

delays

delays finding it
sh and need to stop
lets
l sickness

d need to take detour
g so must park further away from

pace
sport (bus) to terminal

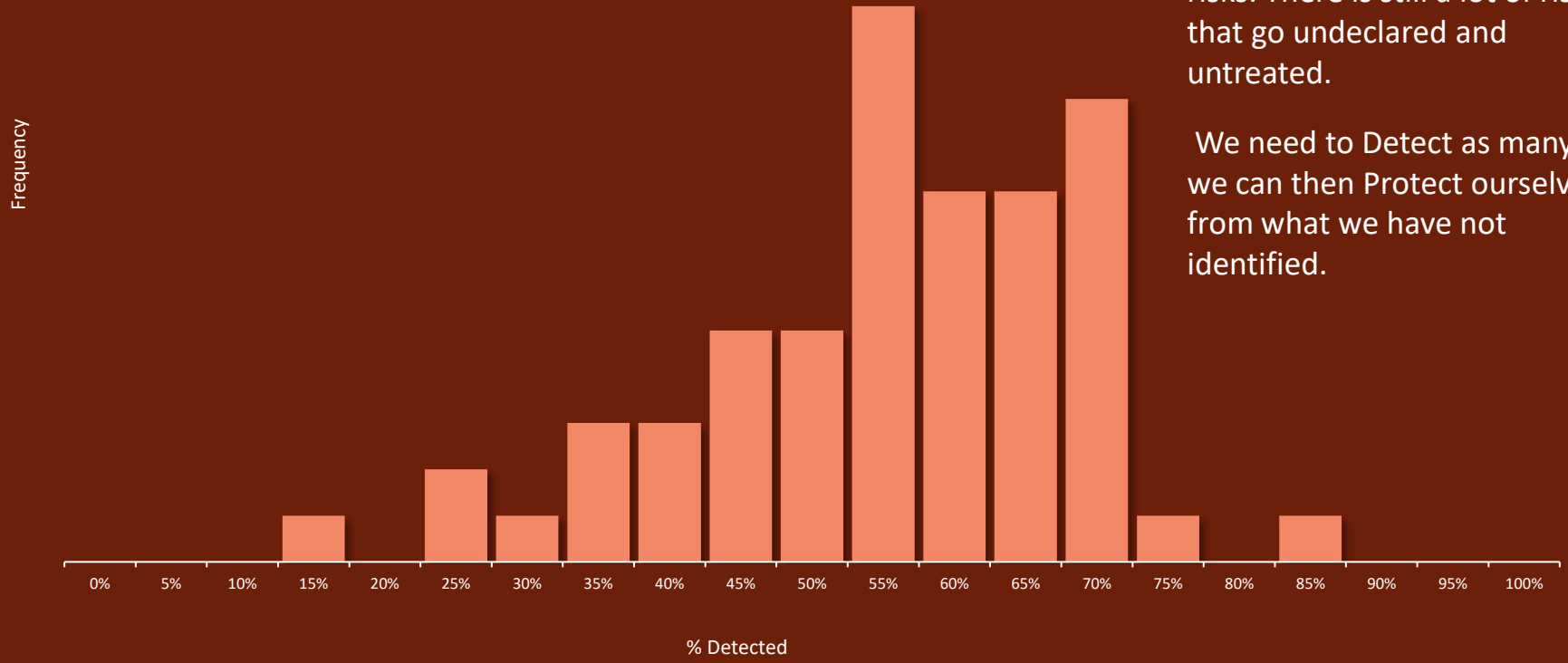
rt
(you must have seen the movies?)

Even simple projects may have many risks, but chances are we will not detect them all.

They are Unknown-Knowns not Unknown-Unknowns. The good news is that we can find them with more effort and "help"

RB

How Many Risks Did We Find?



Working alone, a single person will find on average 53% of the risks. There is still a lot of risk that go undeclared and untreated.

We need to Detect as many as we can then Protect ourselves from what we have not identified.

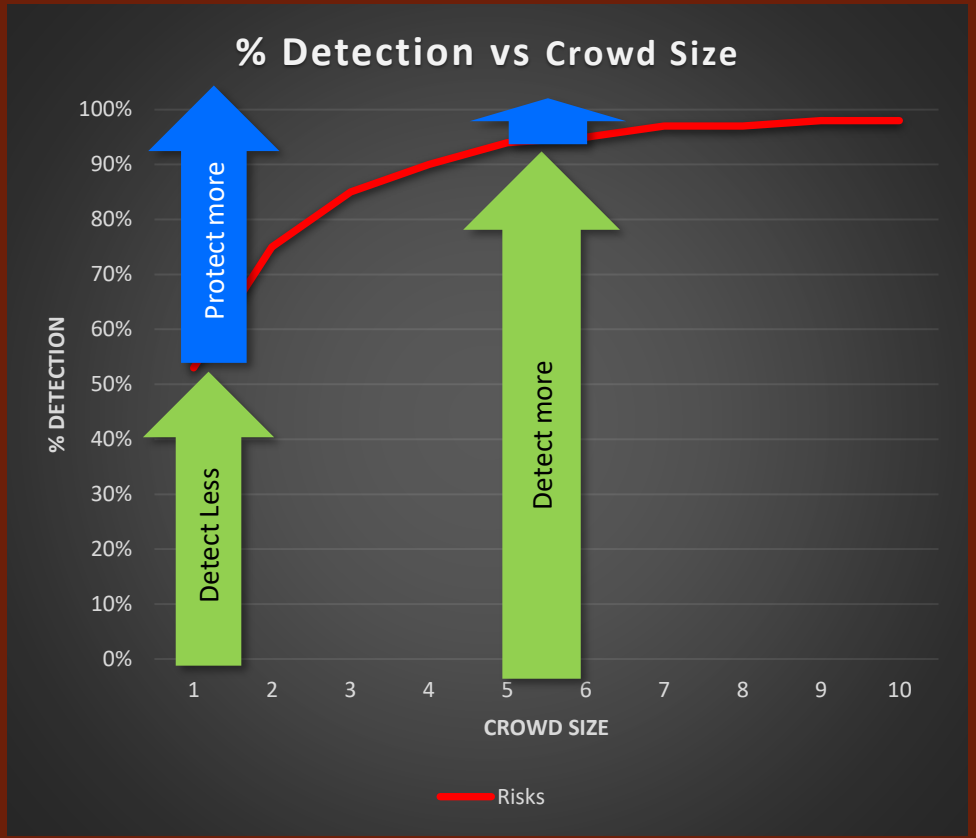
RB

Don’t work alone!

The risks we identify are often shaped by our experience. If you want to increase the success rate of risk identification, you need to access more experience.

The chart shows the effect of the Wisdom of the Crowd, taking the Risks from many people. This is just a guide as this chart will depend on the topic and experience of the team.

Again, we see that even with a large group, we did not detect 100% of the risks. We need to protect ourselves with reserve



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Detect…..

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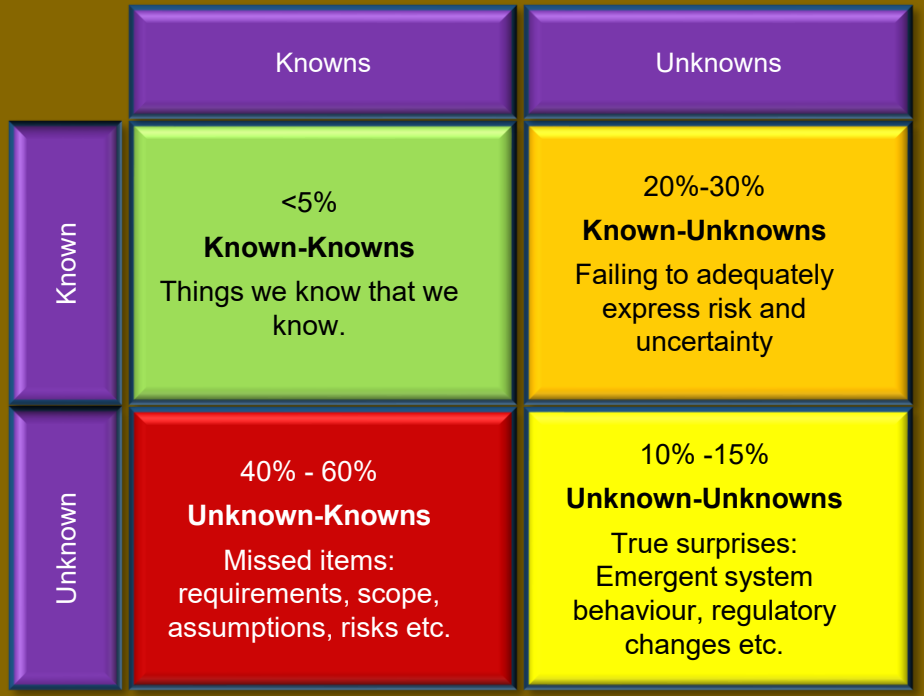
The chart is a synthesis of several studies conducted. The % values represent the magnitude of late surprises and change.

You can replicate this research by allocating your lessons learnt to the 4 quadrants.

So how do we Detect more of those Unknown-Knowns?



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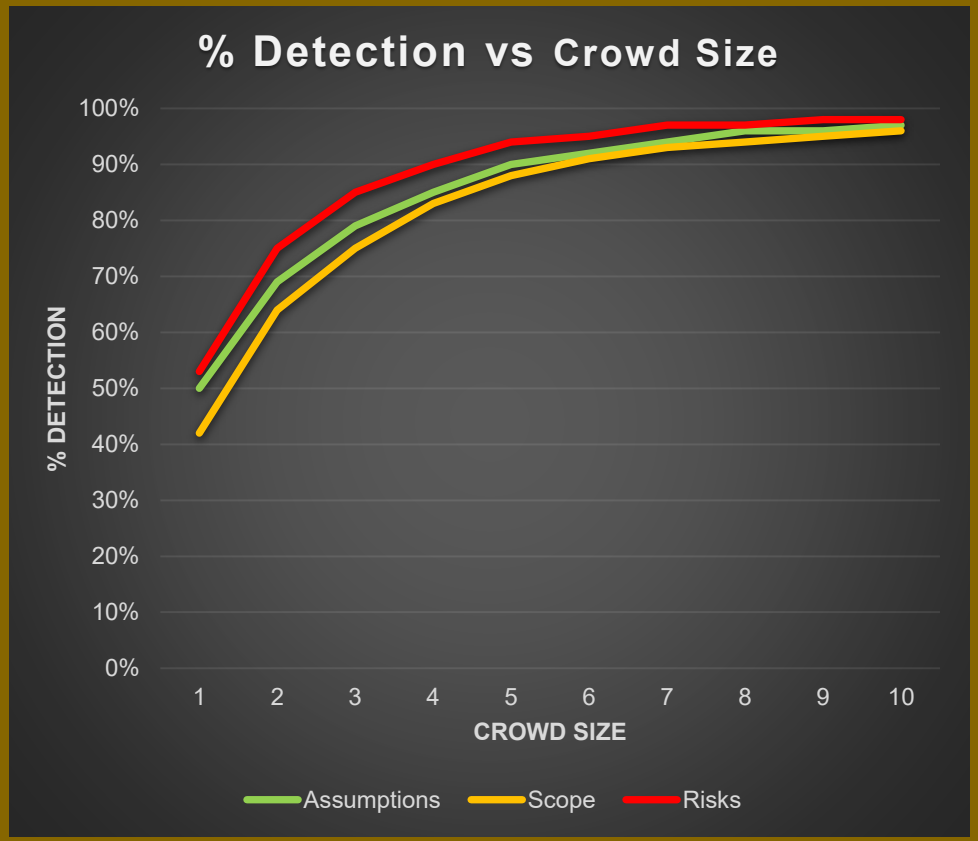

Detect what you can, then protect yourself for what you don't know.

More = More (to a point).

Using many people is one way to tease out project specifics. Detection can be supplemented with prompt lists, check lists, lessons learnt and AI.

It is unlikely you can get to 100%. We must also Protect ourselves from what we don't know.

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…and Protect.

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Two Types of Reserve

We need Reserve for the risks and uncertainties we know about and Reserve for those we don't!

We use terms like Contingency and Management Reserve, but their meanings can vary. So instead, we have referred to the two "buckets" of reserve as Type-1 & Type-2:

Reserve Type-1 is for the risks and uncertainties we know about

Reserve Type-2 is for the risks and uncertainties we don't know about.

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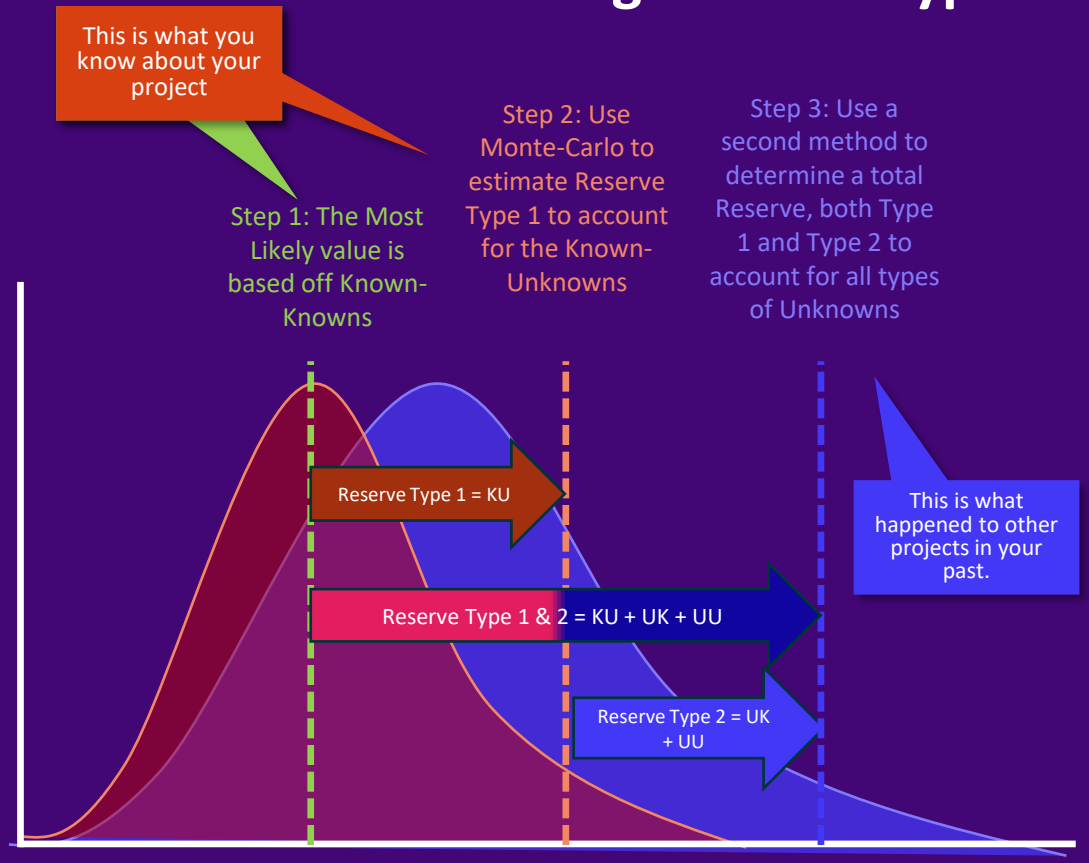
Estimating Reserve Type 1 & 2



1. Most-Likely estimate, derived from what you know you know.
2. Reserve Type 1: Use Monte-Carlo to factor for known Risks and Uncertainties.
3. Reserve Type 1 & 2: But we need to supplement Reserve Type 1 with Reserve to account for what we don't know. There are several ways to do this.

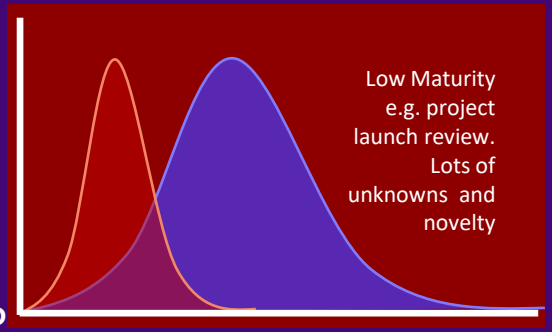
KU=Known0Unknowns. UK=Unknown-Knowns, UU=Unknown0Unknowns.

AP

Factoring for the Unknown

We can only know what we know. This can be fine when we have a good understanding of the project, where there should be few surprises. In such cases Reserve Type 2 might not be necessary.

But the number of Unknowns is likely to increase as we introduce novelty into a project e.g. new technology, methods, materials, suppliers, processes etc. Its hard to know what we don't know when we have never done it before! Its more than Risk and Uncertainties. We don't even know that we don't know.



In the case of novel projects, Monte-Carlo might lead to a "precisely wrong" estimate because it considers only what we Know. The less we know, the more important it becomes to include Reserve-Type-2 to account for what we don't know.

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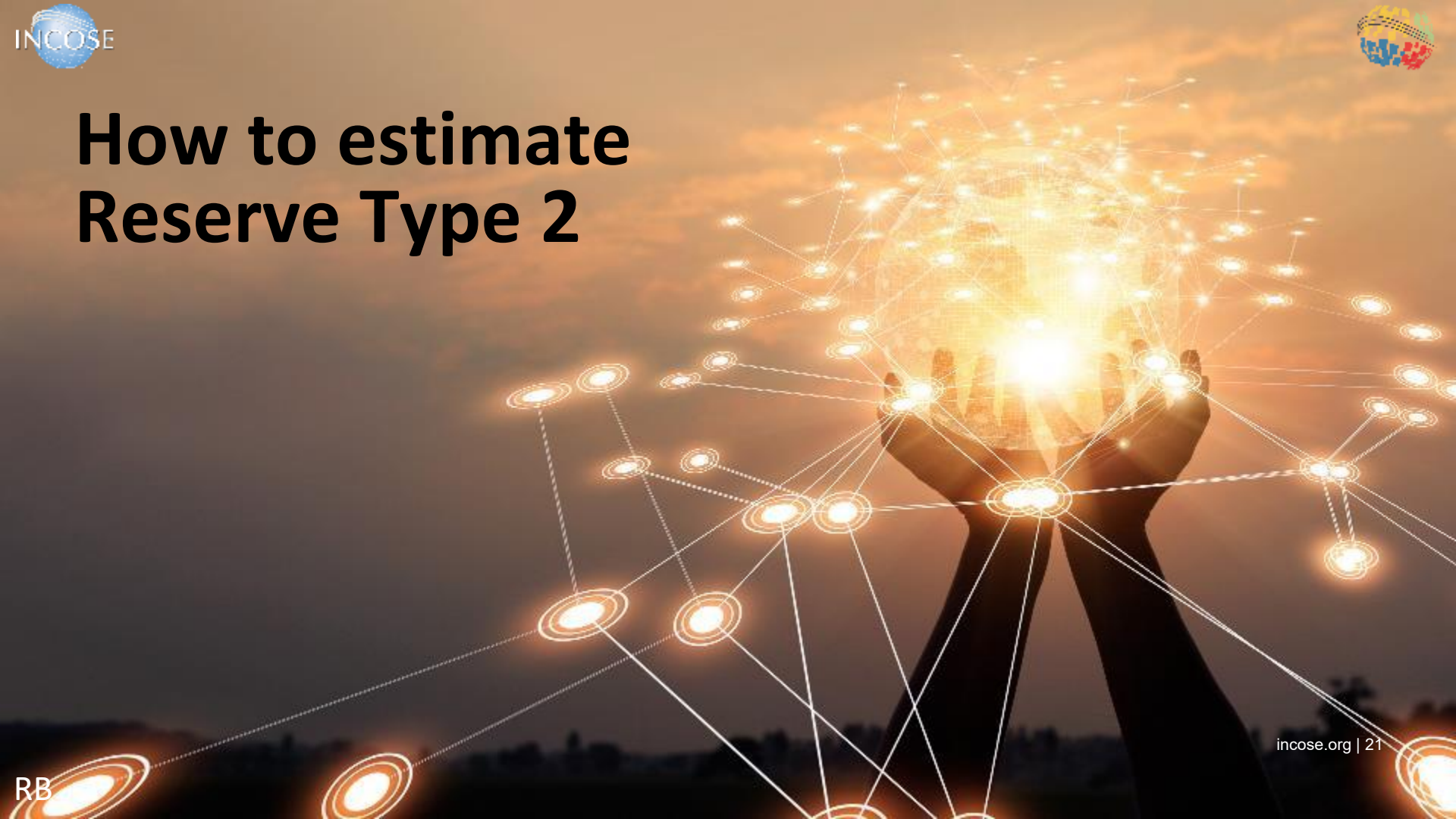
How to estimate Reserve Type 2



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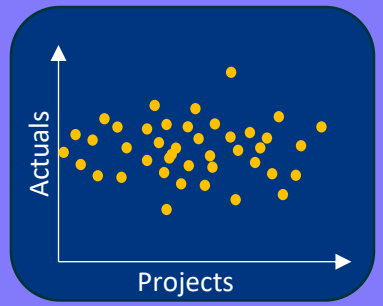
How to estimate what we don't know

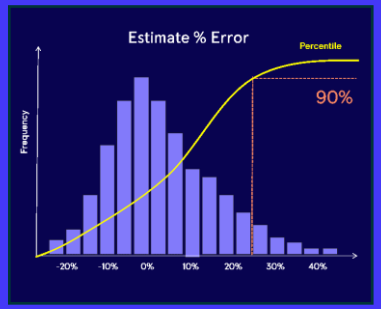
There are three approaches proposed. They all have the same underlying principle, that you need a past to compare to. What was the variance between Estimates and Actuals. As each historic project contains different blends of risks, uncertainties and surprises, the Reserve derived from the variance will account for a historic amount of Reserve Type 1 & 2

1 Historic Variance



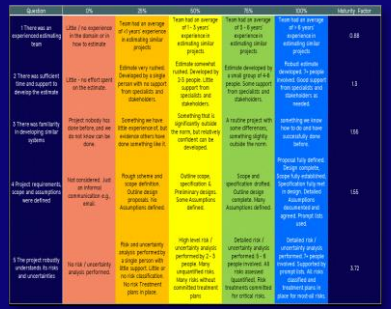
If projects are similar, track actuals e.g. duration of each project in days. Then take a "statistically" meaningful Min, Mid and Max. Reserve Type 1 & 2 will then be *Max_Days minus Mid_Days*.

2 Estimate % Error



If projects are different, measure the % variance between Estimate and Actual. Then take a "statistically" meaningful Mid and Max % Variance. Reserve Type 1 & 2 will then be *%Max minus %Mid*.

3 Estimate Maturity



Use the calibrated score card provided to derive a quantified measure of Estimate Maturity. Link Estimate Maturity to past project % Estimator Error to derive variance

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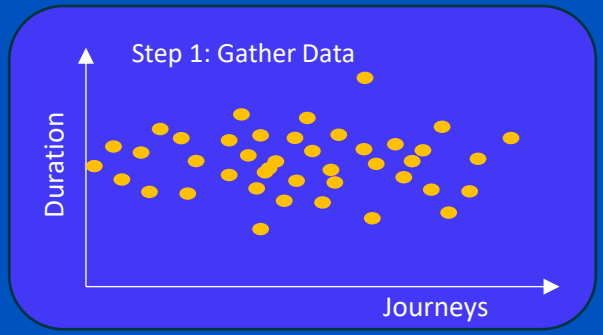
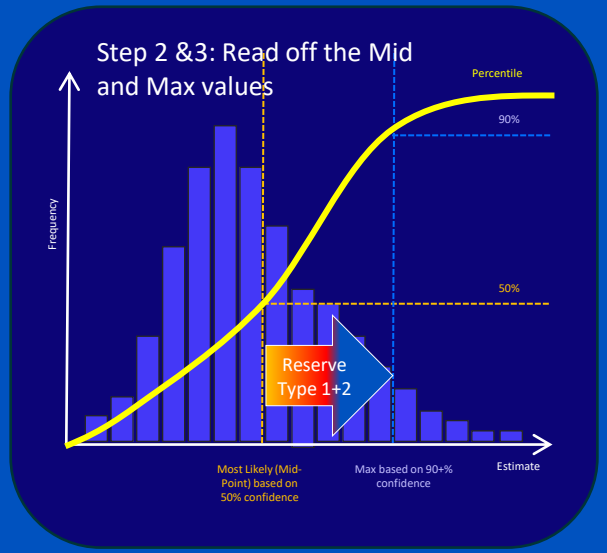
Technique 1: Historic Actuals

Imagine tracking the time it takes you to drive home each day. Each journey will contain different risks, uncertainties and surprises.

Because the data is based in reality, the analysis should include Reserve for all types of Unknowns i.e. Reserve Type 1 + Type 2.

This approach works best when projects are similar. It is less successful for dissimilar projects. If this is the case for you, use the next Technique.





Process

1. Gather actual data on your projects
2. Read off the Mid value e.g. P(50)

   Excel command = Median(*range*)
3. Read off a Max value e.g. P(90)

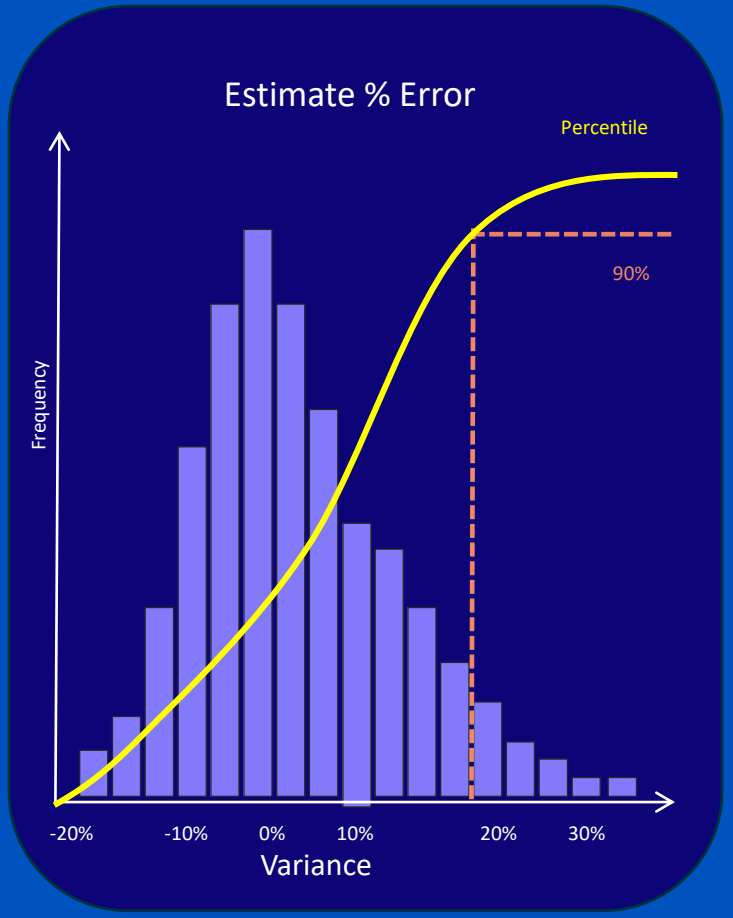
   Excel command = Percentile(*range,90%*)
4. Reserve Type 1 + 2 = Max – Mid

RB

Technique 2: Estimate %Error

Use this approach if projects are different. Normalise out project differences by using the Estimates and Actuals and measuring the % variance. The variances represent a measure of unexpected arisings from all types of unknowns.

But this approach has a “one size fits all” estimate of Reserve Type 1 & 2 and a project might want a more refined forecast of reserve.



Process

1. Create a library of past estimate variance. Track your Estimates and Actuals to derive Variance = (Actual / Estimate) -1
2. Decide what % Confidence you want e.g. 90%.
3. From the past projects (step 1) read off the variance for the chosen % confidence (step 2) e.g. +15% variance.
4. Develop your Most-Likely estimate for your new project as normal e.g. £100
5. Reserve Type 1 & 2 is therefore Step 3 * Step 4 = = £100 * 15% = £15.

RB

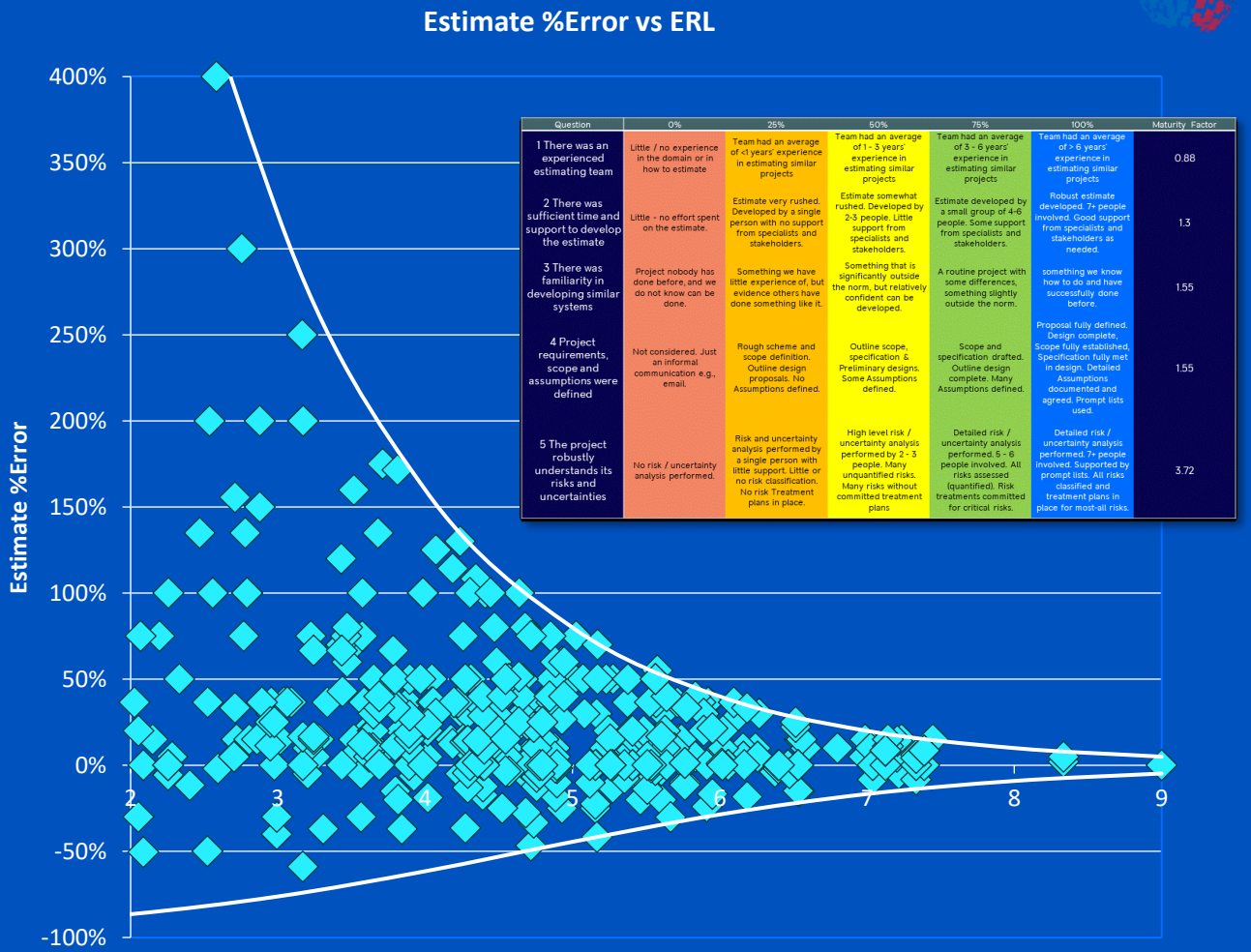
Technique 3: Estimate Maturity

Technique 2 might be unreliable if a project is ahead or behind maturity for a given stage.

Estimate Maturity is a calibrated 5 question checklist derived from a multiple-linear regression linking maturity to % Estimate Error.

If we know the Estimate Maturity, then we can derive a potential Estimate Variance based on past projects with a similar level of maturity.

We now have a “refined” way to estimate the level of Reserve Type 1 & 2 needed.



Question	0%	25%	50%	75%	100%	Maturity Factor
1 There was an experienced estimating team	Little / no experience in the domain or in how to estimate	Team had an average of <1 years' experience in estimating similar projects	Team had an average of 1 - 3 years' experience in estimating similar projects	Team had an average of 3 - 6 years' experience in estimating similar projects	Team had an average of > 6 years' experience in estimating similar projects	0.88
2 There was sufficient time and support to develop the estimate	Little - no effort spent on the estimate.	Estimate very rushed. Developed by a single person with no support from specialists and stakeholders.	Estimate somewhat rushed. Developed by 2-3 people. Little support from specialists and stakeholders.	Estimate developed by a small group of 4-6 people. Some support from specialists and stakeholders.	Robust estimate developed. 7+ people involved. Good support from specialists and stakeholders as needed.	1.3
3 There was familiarity in developing similar systems	Project nobody has done before, and we do not know can be done.	Something we have little experience of, but evidence others have done something like it.	Something that is significantly outside the norm, but relatively confident can be developed.	A routine project with some differences, something slightly outside the norm.	something we know how to do and have successfully done before.	1.55
4 Project requirements, scope and assumptions were defined	Not considered. Just an informal communication e.g., email.	Rough scheme and scope definition. Outline design proposals. No Assumptions defined.	Outline scope, specification & Preliminary designs. Some Assumptions defined.	Scope and specification drafted. Outline design complete. Many Assumptions defined.	Proposal fully defined. Design complete, Scope fully established, Specification fully met in design. Detailed Assumptions documented and agreed. Prompt lists used.	1.55
5 The project robustly understands its risks and uncertainties	No risk / uncertainty analysis performed.	Risk and uncertainty analysis performed by a single person with little support. Little or no risk classification. No risk Treatment plans in place.	High level risk / uncertainty analysis performed by 2 - 3 people. Many unquantified risks. Many risks without committed treatment plans	Detailed risk / uncertainty analysis performed. 5 - 6 people involved. All risks assessed (quantified). Risk treatments committed for critical risks.	Detailed risk / uncertainty analysis performed. 7+ people involved. Supported by prompt lists. All risks classified and treatment plans in place for most-all risks.	3.72

RB

Estimate Maturity

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AP

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1 There was an ex…	Little / no experience in	Team had an average of <1 years' experience in …ing similar …cts	Team had an average of 1 - 3 years' experience in estimating similar projects	Team had an average of 3 - 6 years' experience in estimating similar	Team had an average of > 6 years' experience in estimating similar projects	0.88
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Q1 75% * 0.88

Q2 50% * 1.3

Q3 100% * 1.55

Q4 25% * 1.55

Q5 50% * 3.72

Total: 5.1 Suitable for project launch

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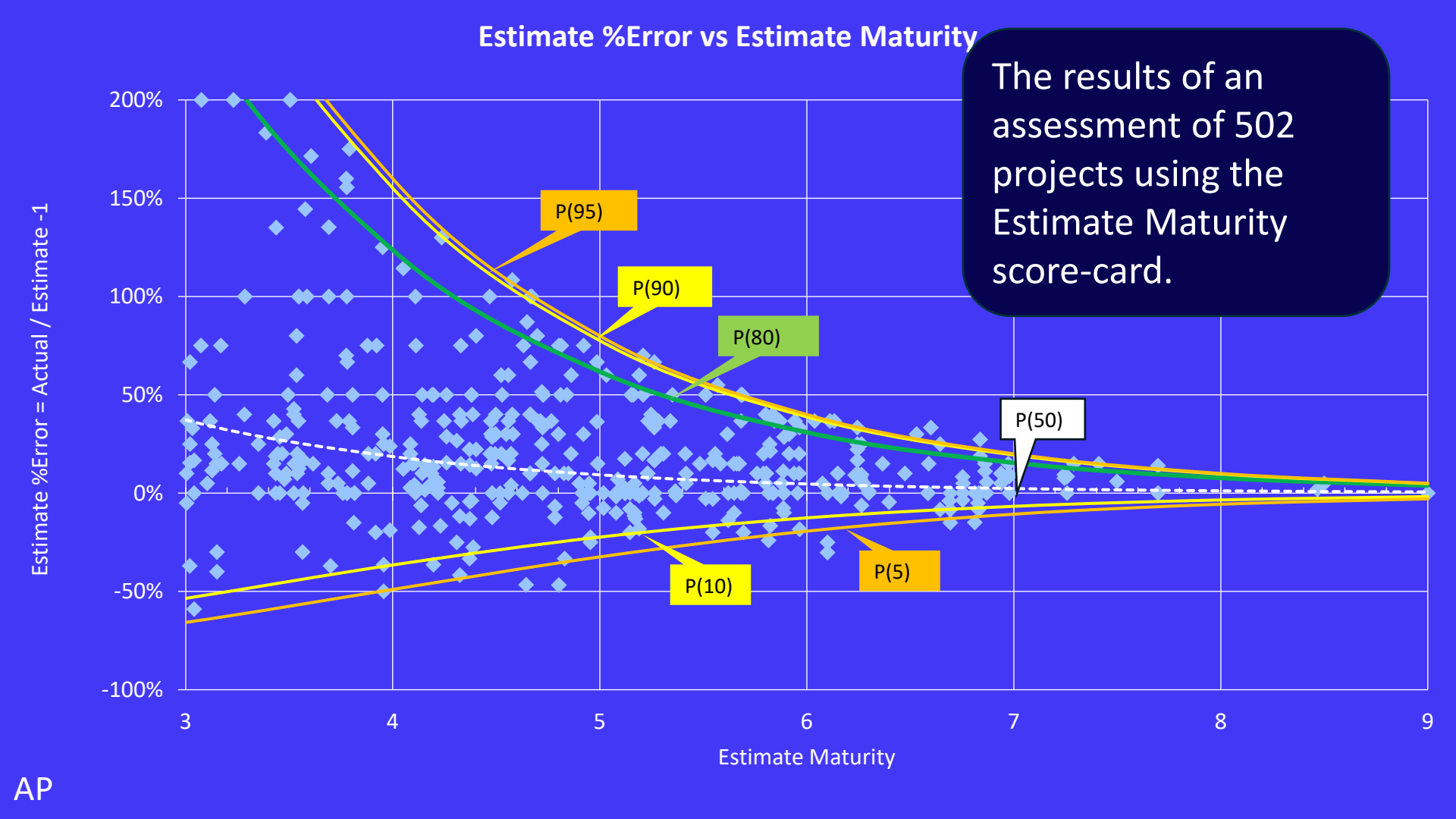
Estimate %Error vs Estimate Maturity
The results of an assessment of 502 projects using the Estimate Maturity score-card.
P(95)
P(90)
P(80)
P(50)
P(10)
P(5)
200%
150%
100%
50%
0%
-50%
-100%
3
4
5
6
7
8
9
Estimate %Error = Actual / Estimate -1
Estimate Maturity
AP

Reserve Type 1 & 2

Estimate Maturity	5% confidence	10% confidence	50% confidence	80% Confidence	90% Confidence	95% Confidence
9	-2%	-1%	0%	2.5%	4%	4.8%
8	-3%	-1%	1%	5%	7.7%	9.7%
7	-7%	-3%	2%	10%	15.5%	19.4%
6	-13%	-6%	5%	19%	31%	39%
5	-22%	-11%	9%	39%	62%	78%
4	-37%	-19%	19%	77%	124%	155%
3	-54%	-32%	37%	155%	247%	310%
2	-70%	-49%	74%	309%	495%	620%
1	-82%	-66%	159%	618%	989%	1241%
0	-	-	-	-	-	-

AP

Reserve Type 1 & 2

Estimate Maturity				80% Confidence	90% Confidence	95% Confidence
9				2.5%	4%	4.8%
8				5%	7.7%	9.7%
7				10%	15.5%	19.4%
6				19%	31%	39%
5				39%	62%	78%
4				77%	124%	155%
3				155%	247%	310%
2				309%	495%	620%
1				618%	989%	1241%
0	-	-	-	-	-	-

Scenario 1: A Project estimates a Most-Likely Budget of £1m and a schedule of 12 months. They have an Estimate Maturity of 7 and want to be 90% confident.

Reserve Type 1 & 2 = 15.5%

Budget Reserve = £1m * 15.5% = £0.155m. Schedule Reserve of 12 months * 15.5% = 1.86 months = 8 weeks.

AP

Reserve Type 1 & 2

Estimate Maturity				80% Confidence	90% Confidence	95% Confidence
9				2.5%	4%	4.8%
8				5%	7.7%	9.7%
7				10%	15.5%	19.4%
6				19%	31%	39%
5				39%	62%	78%
4				77%	124%	155%
3				155%	247%	310%
2				309%	495%	620%
1				618%	989%	1241%
0	-	-	-	-	-	-

Scenario 2: A Project estimates a Most-Likely Budget of £1m and a schedule of 12 months. They have an Estimate Maturity of 4 and want to be 90% confident.

Reserve Type 1 & 2 = 124%

Budget Reserve = £1m * 124% = £1.24m. Schedule Reserve of 12 months * 124% = 14.9 months.

AP

Effort vs Estimate Maturity

More = More Effort!

The chart shows the average relative cost to develop an estimate to a given maturity. If you don't want to invest the time, you will Detect less and need to Protect more. If you don't like how much Protection you need, then Detect More and Protect Less.

AP

Conclusions

RB

1. A project will need to estimate two things, (1) their Most Likely and (2) a Plausible Worst case. Both are needed in effective decision making.
2. We could be at risk if we make decisions, and commitments, based only on what we know and not consider what we don’t know.
3. Detect and Protect: Detect what you can, Protect yourself with Reserve from what you don’t know.

RB