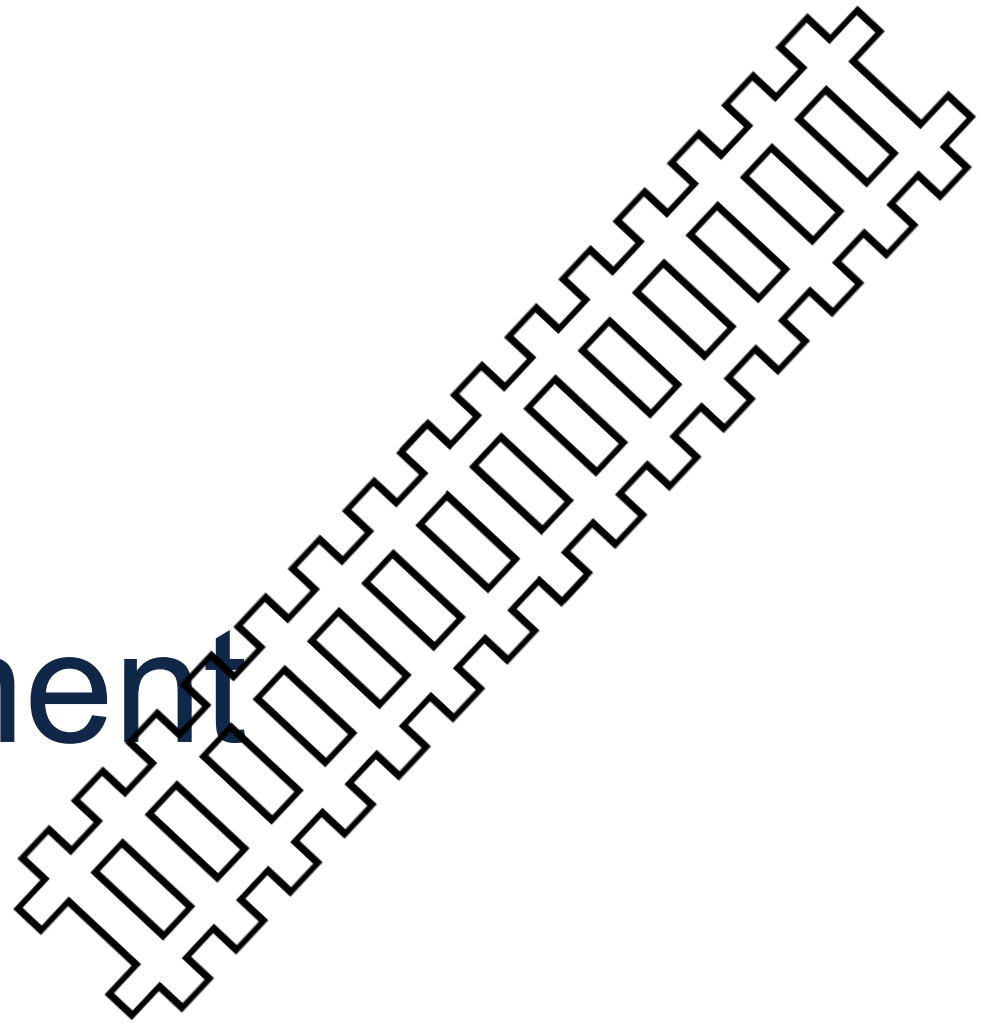
OXFORD GLOBAL PROJECTS

NATIONAL INFRASTRUCTURE COMMISSION



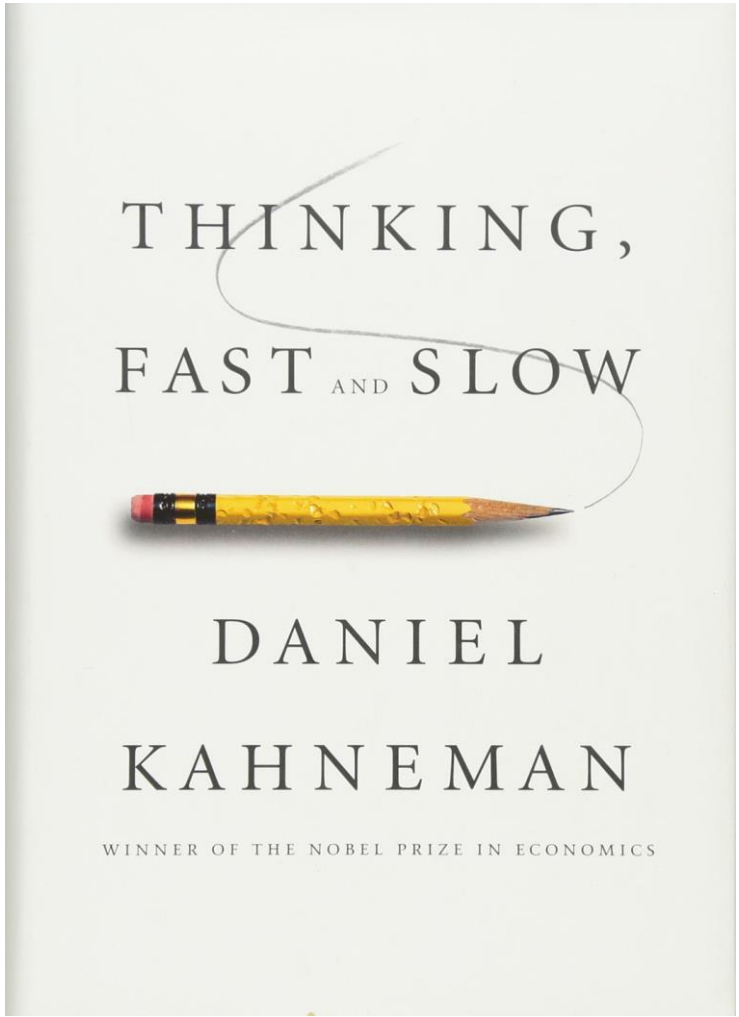
Rail Needs' Assessment

Reference Class Forecast

v5 1st December 2020

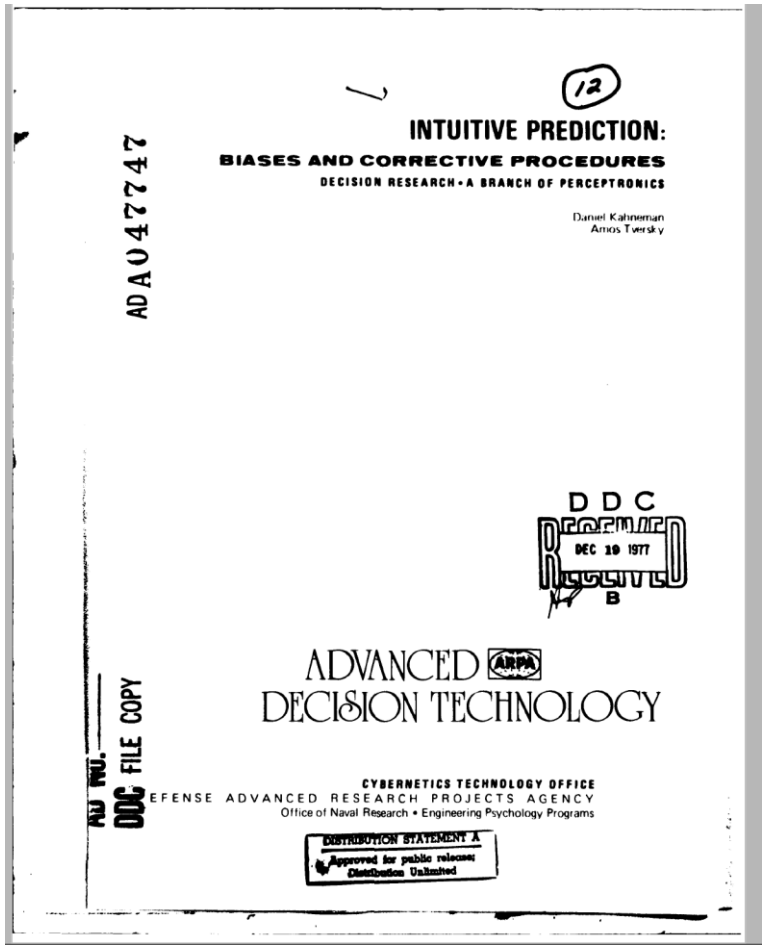
Reference Class Forecasting

Our reference class forecasting tool has been cited by Nobel Laureate Daniel Kahneman as **“the single most important piece of advice regarding how to increase accuracy in forecasting through improved methods.”**



The Big Idea

The **best predictor** of performance in a planned project is actual performance in class of implemented, comparable projects. Reference Class Forecasts do not guarantee accuracy, just **most accurate forecasts**. Method is based on theories that won the Nobel Prize in Economics (planning fallacy, optimism bias).

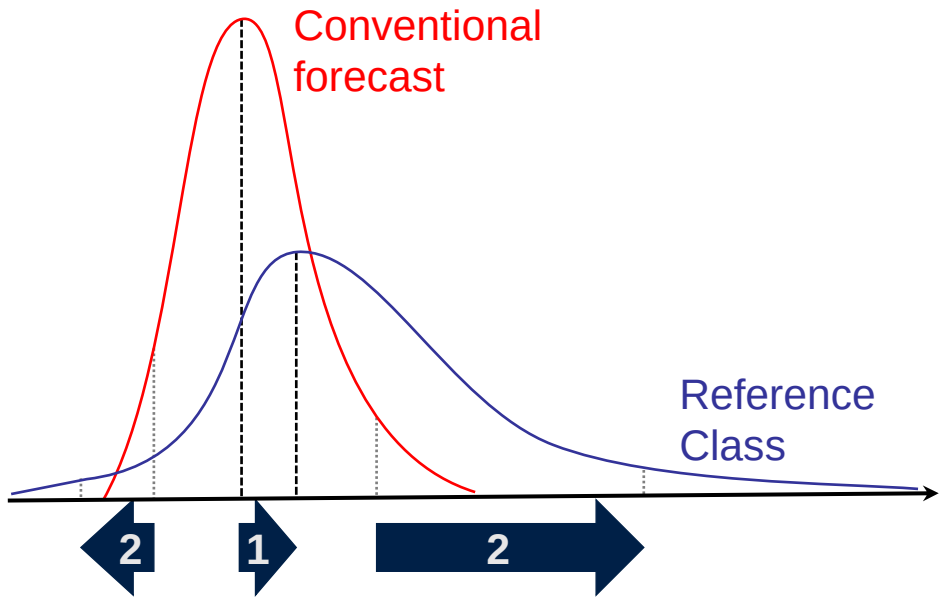


3 Steps of RCF

1. Identify relevant reference class of past, similar projects.
2. Establish probability distribution for the selected reference class.
3. Compare specific project with distribution, in order to establish most likely outcome.

What RCF Does

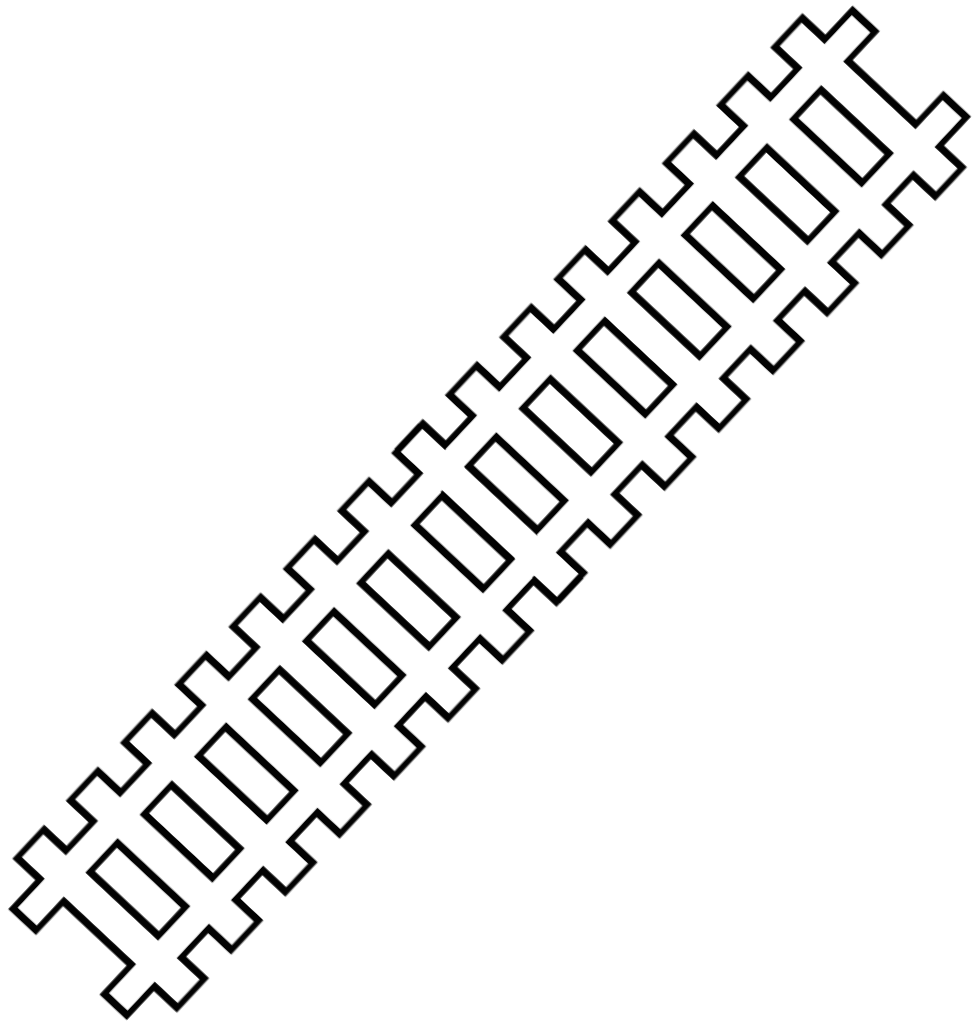
In Statisticians' language RCF regresses the best guess toward the most likely case of the reference class of past, similar projects (1) and expands the estimate of the interval to the interval of the reference class (2).



Unknown-unkowns

RCF is the only existing method that takes into account “unknown unknowns”. How? By incorporating in the reference class ALL effects on performance, including “unknown unknowns”.

Developing the Reference Class



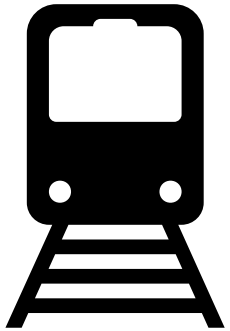
Project Risk Factors

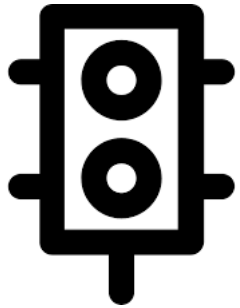
As much information as possible is gathered for the target project and this is compared to data available for other completed projects.

For example rail projects can be broken down into asset types of:

- Civil works
- Track works
- Signaling

Typically the cost breakdown, anticipated schedule duration(s) and maturity (stage of approval) of the project is required.





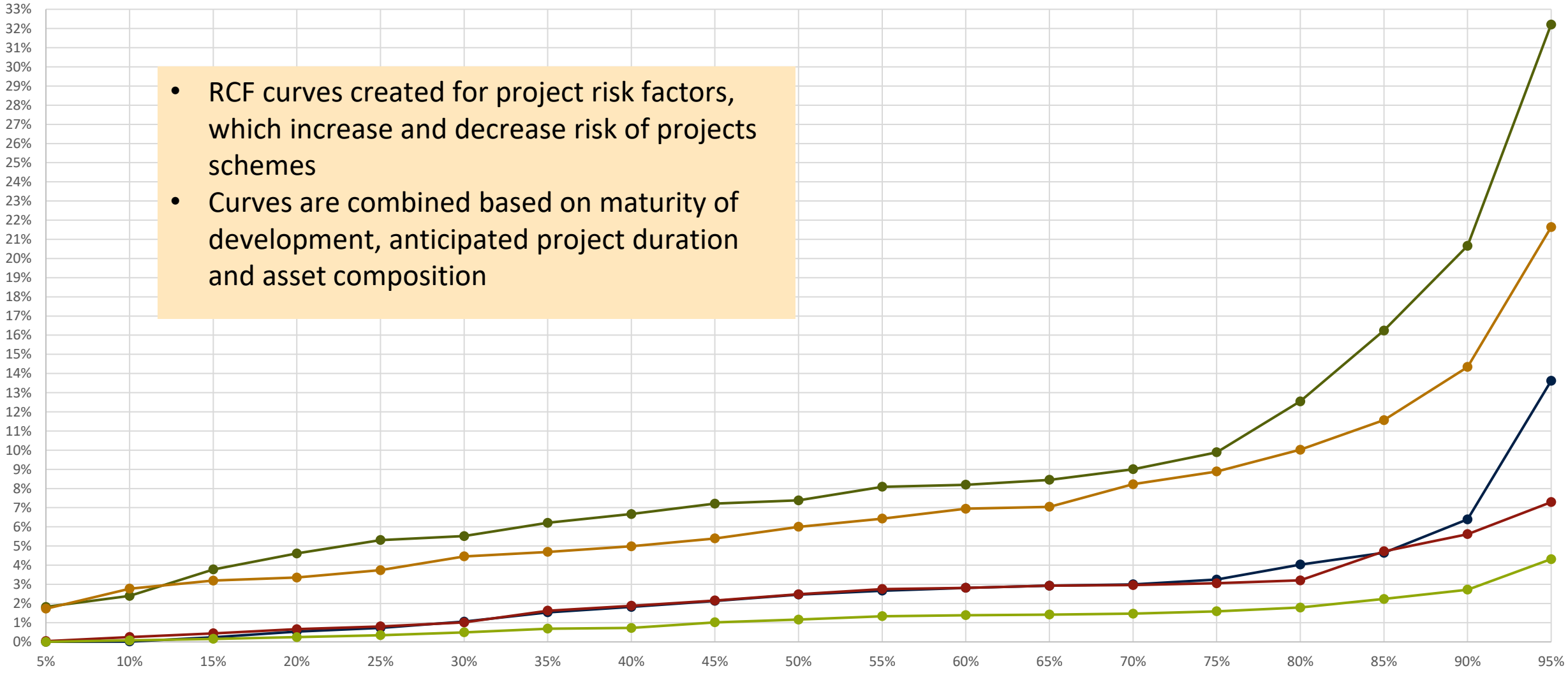
Data source used for NIC

	Land & Property	Stations	Track	Electrification	Signalling/testing	Civils (embankments/ cuttings/ road works)	Utilities	Tunnels	Bridges/ viaducts	Temporary works	Other buildings (depots etc)	Prelims
Number of Projects in Sample	48	21	355	50	5303	1598	24	61	56	149	149	1725
Source Region												
Asia		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Africa			✓	✓	✓	✓		✓	✓	✓	✓	✓
Europe	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
North America		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
South America			✓		✓	✓		✓	✓	✓	✓	✓
Oceania			✓		✓	✓		✓	✓	✓	✓	✓
Frequency of cost overrun	4 out of 10	7 out of 10	7 out of 10	4 out of 10	4 out of 10	8 out of 10	8 out of 10	7 out of 10	6 out of 10	7 out of 10	7 out of 10	8 out of 10

Data date range:	Data predominantly sourced from 1990 to date plus further projects dating back as far as 19th century - when data able to be validated.

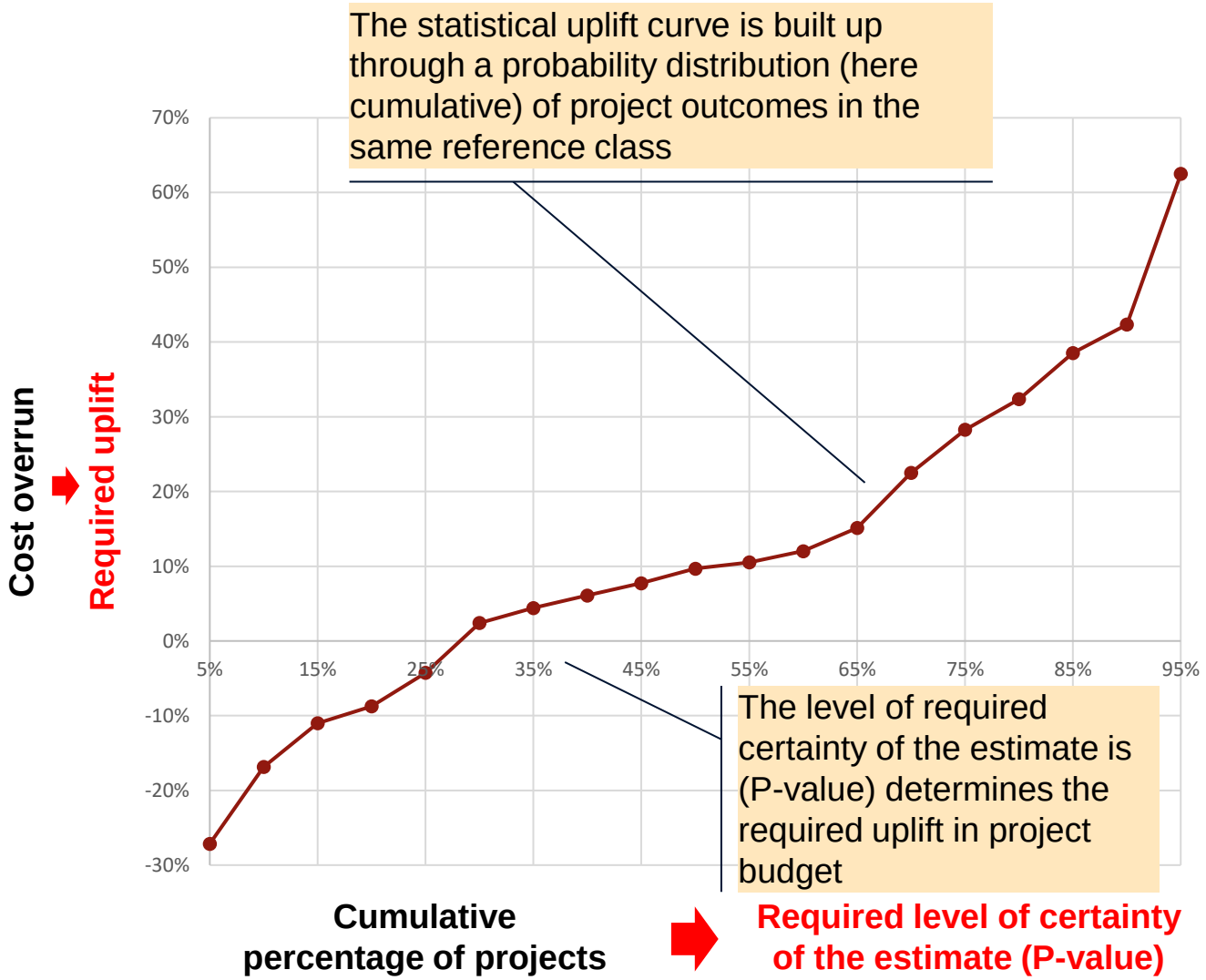
RCF curves for project risk factors

- RCF curves created for project risk factors, which increase and decrease risk of projects schemes
- Curves are combined based on maturity of development, anticipated project duration and asset composition



Output: RCF curves

The output of the RCF is an S-curve, here of project risk. The S-curve turns historic information into forward looking management insight.



What to do with the output

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1. Business Case Test

- Is it appropriate to continue with the scheme *if* it could outturn in the “worse case” tail of comparable historic projects?

2. Enhanced Risk Management

- What *more* can be done to avoid problems which might have caused the “worse case” projects and seek opportunities which delivered the better outcomes?

3. Target performance

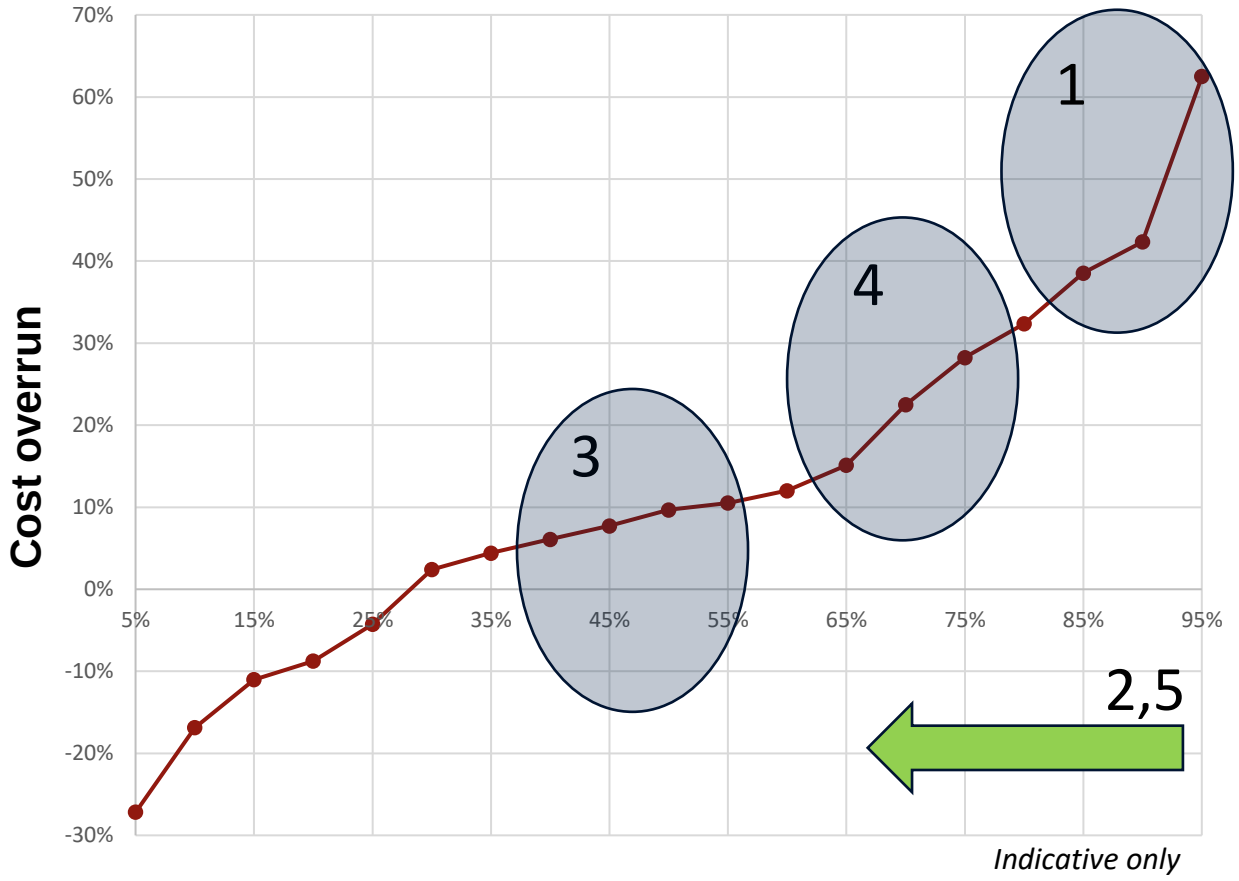
- What are pragmatic targets for teams to aim for (this might consider any internal risk analysis)?

4. Risk Appetite

- What is the risk appetite for setting cost contingency (or schedule buffer) and target outcomes (this too could consider an internal risk analysis)?

5. Incentivise outperformance

- What hard internal mechanisms will be introduced to maintain the incentive to achieve the targets and not use up contingency inefficiently?



Further Insights

RCF and QRAs

- The RCF range of potential outcomes is based on the actual outcomes of comparable projects. RCF provides an "external" view.
- QRA is based on the potential range of outcomes based on the identified uncertainties and risks in a project.
- QRA does not include unknown risks and uncertainties, which RCF does.
- QRAs are still very useful to set targets within teams since these are based on the team's best knowledge; enabling teams to be held to account for the items which are wholly within their capability to manage.
- RCF provides key stakeholders with a more rounded perspective to check that projects are still worth pursuing should the unfortunate happen – or enable sufficient reserves to be identified.

Contingency and change management

- Using RCFs to provide additional "reserves" can be seen as an easy option to resolve issues. Strong contingency management processes are needed to make sure the reserves are only used as a last resort and when it is clearly evident that significant &/or unforeseen risks have occurred.

Scope changes

- Whilst RCF does reflect a degree of scope change since this is intrinsic within the historic dataset it does not allow for major scope change that would be significantly different to historic cases (e.g. changing a rail bridge to a multi-modal link). Change control processes should always be maintained to secure additional funding based on cost-benefit analyses.

Portfolio effects

- RCF considers projects on an individual basis. Where multiple projects are being funded simultaneously a portfolio analysis should be undertaken to determine the most appropriate aggregate range of outcomes.
- However, major projects often dominate portfolios meaning that the risk of a few projects dominate the portfolio.

RCF assumptions

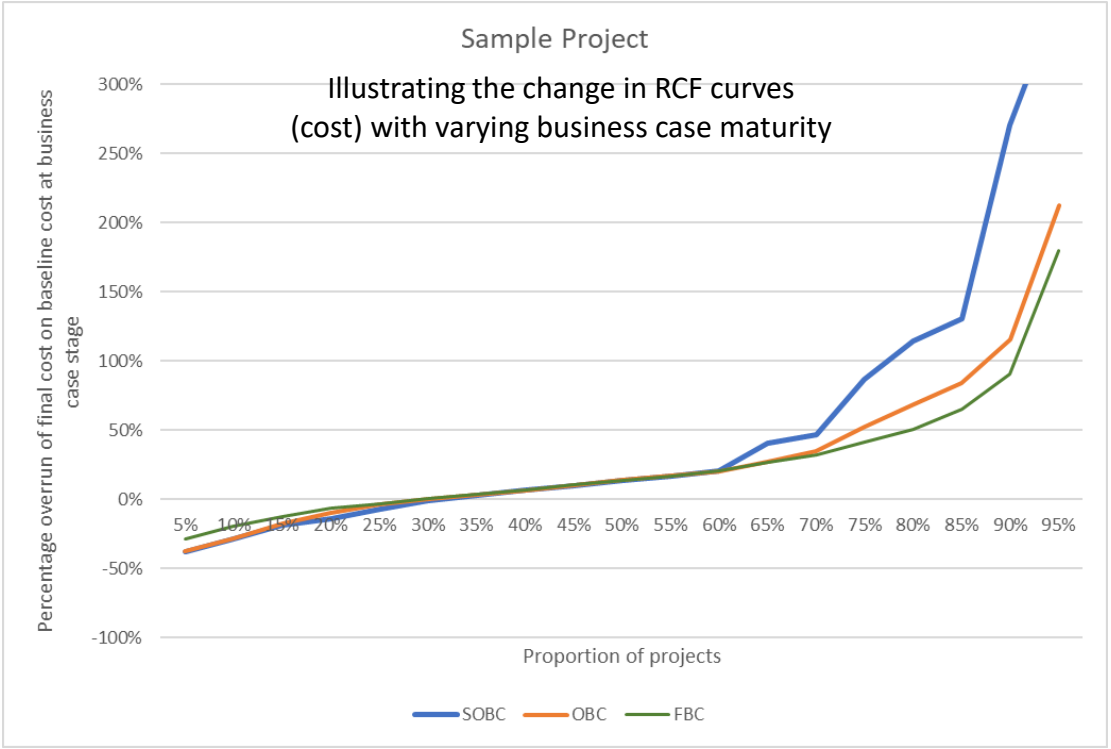
- RCF uses historic data of completed projects. Thus a key assumption is that the project under consideration is expected to perform as well (or badly) as past projects.
- Thus, projects could be riskier than the RCF suggests if they are – for example – built in a more complex environment, introduce a high level of innovation, or face larger amounts of regulation.
- On the other hand, projects could identify clear plans to improve on historic project performance which might mean they are less risky than previous project performance suggests.

What the RCF's tell us

These RCF curves (for an example project) reflect the actual outturn versus projected baseline cost for a portfolio of historic projects, as subdivided into key activities. Projects at the right hand side constitute "high risk" and those at the left hand end "low" risk.

Key characteristics / observations :

- 1 in 3 projects finish within budget (overrun ≤ 0%)
- 50% of projects had a cost overrun up to 14% and 50% higher than 14%
- There is greater propensity for overspend to underspend and the size of overspend is much higher than the potential underspend (hence driving a higher mean value of 54% at SOBC, 30% at OBC and 26% at FBC).
- There is a reasonably consistent variability of +/- 30% for 60% of projects regardless of the business stage.
- In 1/3 of projects there is little movement (i.e. risk reduction) from RCF30 to RCF60 which is probably due to relative stability in project estimates/ complexity in the front end. It is also probable that many projects in this range are "standard" (low risk) type projects and mature .
- Early business case stages illustrate greater uncertainty in the tail which is likely to reflect significant concept and scope shift in a subset of projects
- Increasing maturity reduces the potential risk impact at confidence levels greater than RCF60 with, at RCF80:
    - A drop in potential risk impact from 115% to 70% between SOBC and OBC; and
    - A reduction between OBC and FBC from 70% to 50%
- Extreme overruns doubling or even tripling budgets are still possible.
- The tail grows exponentially, reflecting significant but rare events (black swans)
- Setting contingency at higher values has little effect on reducing volatility.



What the RCF's tell us

This graph illustrates the difference between the base RCFs used to calculate the "blended" project RCFs (at SOBC).

Key characteristics/ observations:

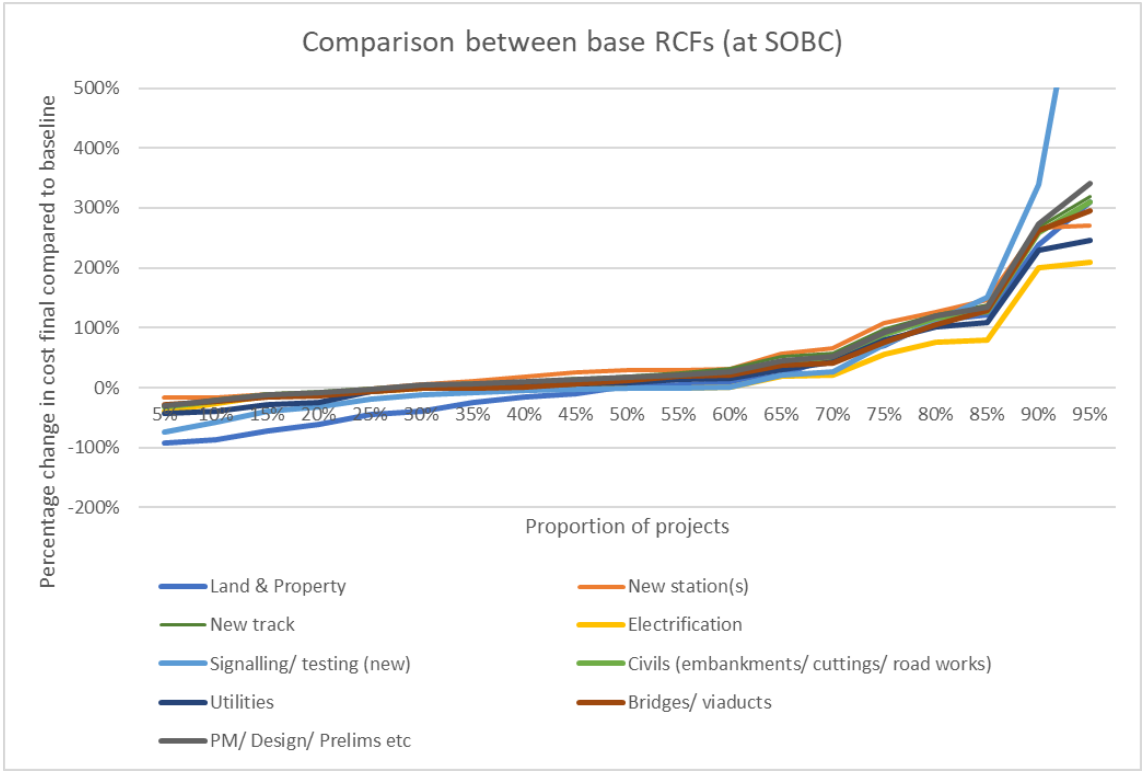
- The base RCFs have a variability range of
  - 8% to 30% at RCF50; and
  - 76% to 130% at RCF80

- "Signalling/ testing" has a significantly greater volatility above RCF85 this is influenced by use of statistically comparable IT projects in the RCF data

- Reduced volatility in some aspects can be due to
  - Greater flexibility in scope flexibility
  - Influence of up front purchase (e.g. TBMs in Tunnelling
  - – purchase price influential then only susceptible to significant events – increased predictability

- Higher volatility can be due to
  - Magnitude of interfaces (e.g. signalling/ testing requires all other components to be at an advanced state)
  - Greater separation from decision points (e.g. signalling/ testing design may be only indicative when civils are fully detailed)

- It has been observed that RCFs using subdivided RCFs (by asset type) do not always reflect the volatility of the complete original "host" project.



The NIC Rail Needs' Assessment RCF

A base model has been created by OGP to assess the potential volatility of projects identified.

The particular project's asset composition by cost together with information on maturity stage (e.g. GRIP stage) and schedule is entered into the model:

Scheme Composition	Est £	or %age
Land/ property		
New station(s) build (note 2)		
Refurbished station(s) work (Note 2)		
New track		
Track upgrade		
Electrification		
Signalling/ testing (new)		
Signalling/ testing (upgrade)		
Civils (embankments/ cuttings/ road works)		
Utility works		
Tunnels		
Bridges/ viaducts		
Temporary works		
Other buildings (depots etc)		
IT (hardware/ software)		
PM/ Design/ Prelims etc		

Development Stage:		GRIP Stage

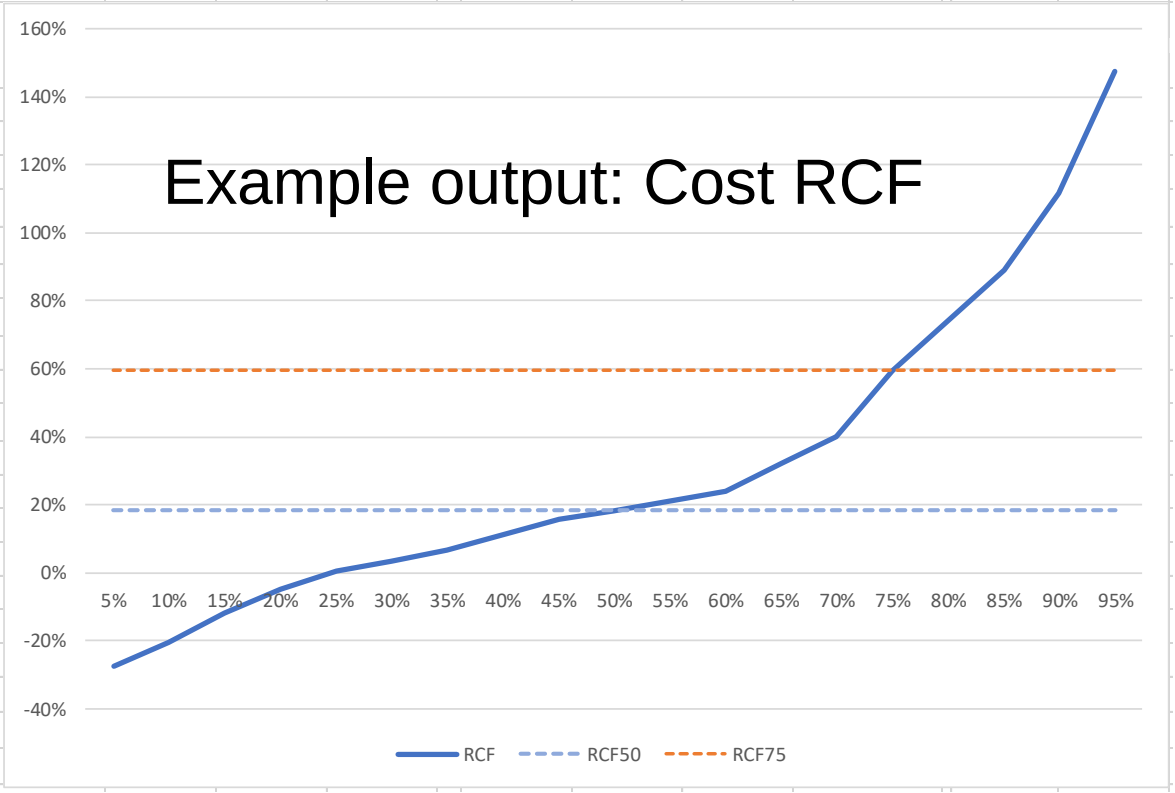
Schedule Information	
Timenow:	01/11/2020
Key Dates	
Design start: (GRIP 4 start or equivalent):	
Delivery start: (GRIP 6 start or equivalent):	
Delivery end: (GRIP 6 end or equivalent):	
Durations:	Months
Design to completion (e.g. GRIP 4 to end 6)	
Delivery period (e.g. GRIP 6 start to finish):	

Output

The asset composition is used to determine which RCF base data is appropriate and these aggregate to generate blended, project specific RCFs for cost and schedule.

Desired RCF Values:	RCF50	%age Contingency:	18%	RCF75	%age Contingency:	59%	Mean: [3]	31%

Pvalue	RCF (P)	RCF
P0	0%	
P5	5%	-28%
P10	10%	-21%
P15	15%	-12%
P20	20%	-5%
P25	25%	0%
P30	30%	4%
P35	35%	7%
P40	40%	11%
P45	45%	16%
P50	50%	18%
P55	55%	21%
P60	60%	24%
P65	65%	32%
P70	70%	40%
P75	75%	59%
P80	80%	74%
P85	85%	89%
P90	90%	112%
P95	95%	148%
P100	100%	



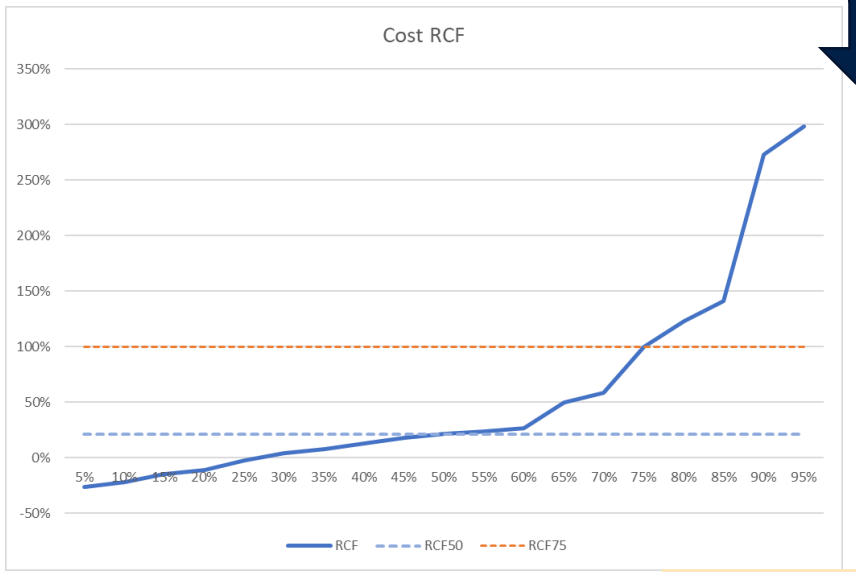
A desired "Risk Appetite" e.g. RCF percentile* (e.g. RCF50/ RCF75) is chosen and the requisite value for contingency (or float) is portrayed.

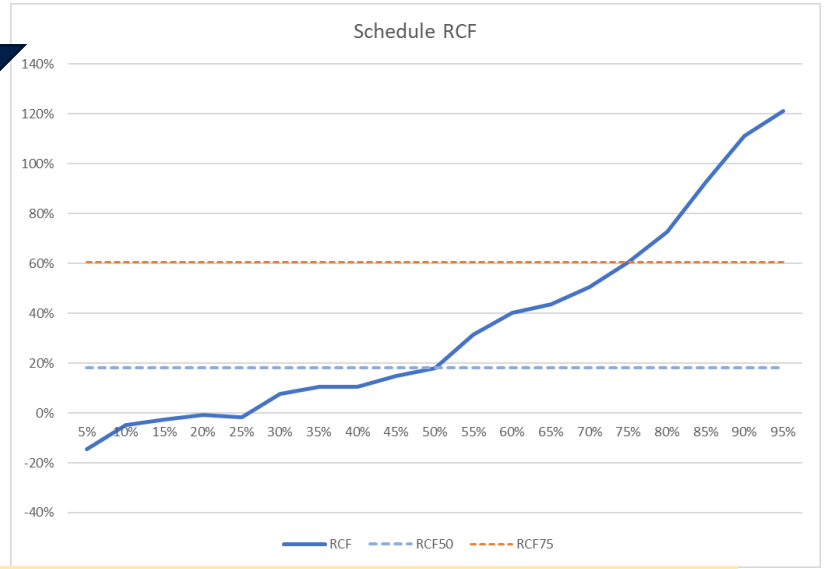
** The RCF percentile represents a percentage of projects, based on the RCF data, which would have been delivered within this amount of contingency (or for schedule, within this amount of float) – had that amount been available at the project's development stage.*

Example results

RCF curves for a theoretical new station build at pre-GRIP2 of cost composition:

- Station Build: 50%
- Track upgrade: 5%
- Utility works: 20%
- Temp works: 10%
- PM Prelims etc: 15%





The RCF suggests

- 21% contingency to attain a RCF50 confidence level and 100% contingency to attain a RCF75 confidence level; and
- 18% (RCF50) or 61% (RCF75) schedule float

On a 5-year target (zero float) programme, this would suggest an additional 11 months for RCF50 and 36 months for RCF75
In most cost compositions, schedule and cost are reasonably aligned at RCF50 whilst at higher RCFs, schedule excesses tend to be lower than the comparable cost excesses.