Abstract

- This paper will consider the spectrum of parametric cost models from cost estimating relationships (CER) to micro and finally macro-parametric models. This will lead to a description of the Family of Advanced Cost Estimating Tools (FACET) parametric suite of models and their top-down capability to estimate costs.
- One of the unique aspects of FACET is the utilisation of multi-colinearity. Typically, in cost research we are taught to discard one of the independent variables which exhibits this characteristic, but QinetiQ used it to enhance the accuracy of parametrics through the comparison of performance and design characteristics, thus improving the confidence in the model input parameters.
- FACET is also unique amongst commercial parametric models in the combination of input data uncertainty and CER uncertainty. This parametric model has a cost output that is a realistic tolerance considering the attributes of the uncertainties of the historical data used to form the CER and the data characteristics of the future project which is being predicted.
- Finally, this FACET model has a unique approach to the seamless transition from performance based cost estimating to design based cost estimating depending upon the uncertainty in the inputs characteristics.
- This paper will explore the cost research conducted by QinetiQ and the implementation of the research into the 80+ QinetiQ FACET models that have been licenced by customer around the world.

Macro-parametrics and the applications of multi-colinearity and Bayesian to enhance early cost modelling

International Cost Estimating and Analysis Association (ICEAA)

9th to 12th June 2015

Dale Shermon

QinetiQ Fellow / Head of Profession Cost Engineering

Dr Catherine Barnaby

Head of Cost Research

Agenda

1. QinetiQ Procurement Advisory Services
2. Macro-parametric cost estimating
3. Family of Advanced Cost Estimating Tools (FACET)
4. Multi-colinearity
5. Performance and Design based estimating
6. Data and CER uncertainty
7. Summary

Knowledge Base Estimating philospohy

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2.

Macro-parametric cost estimating

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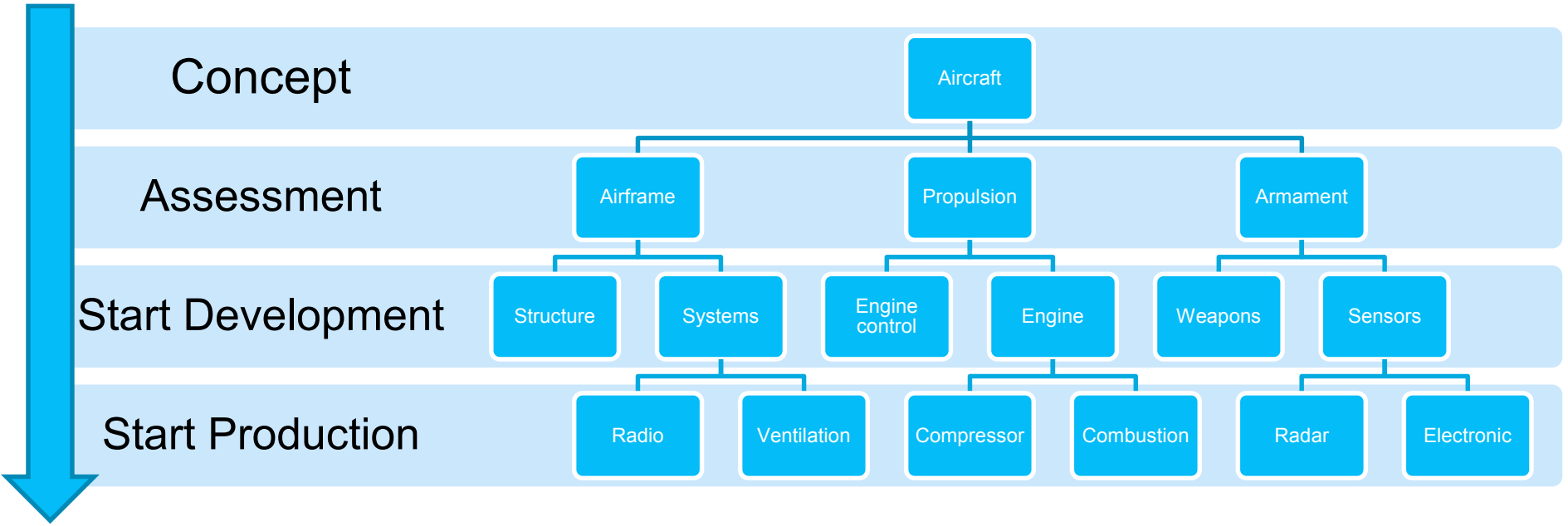
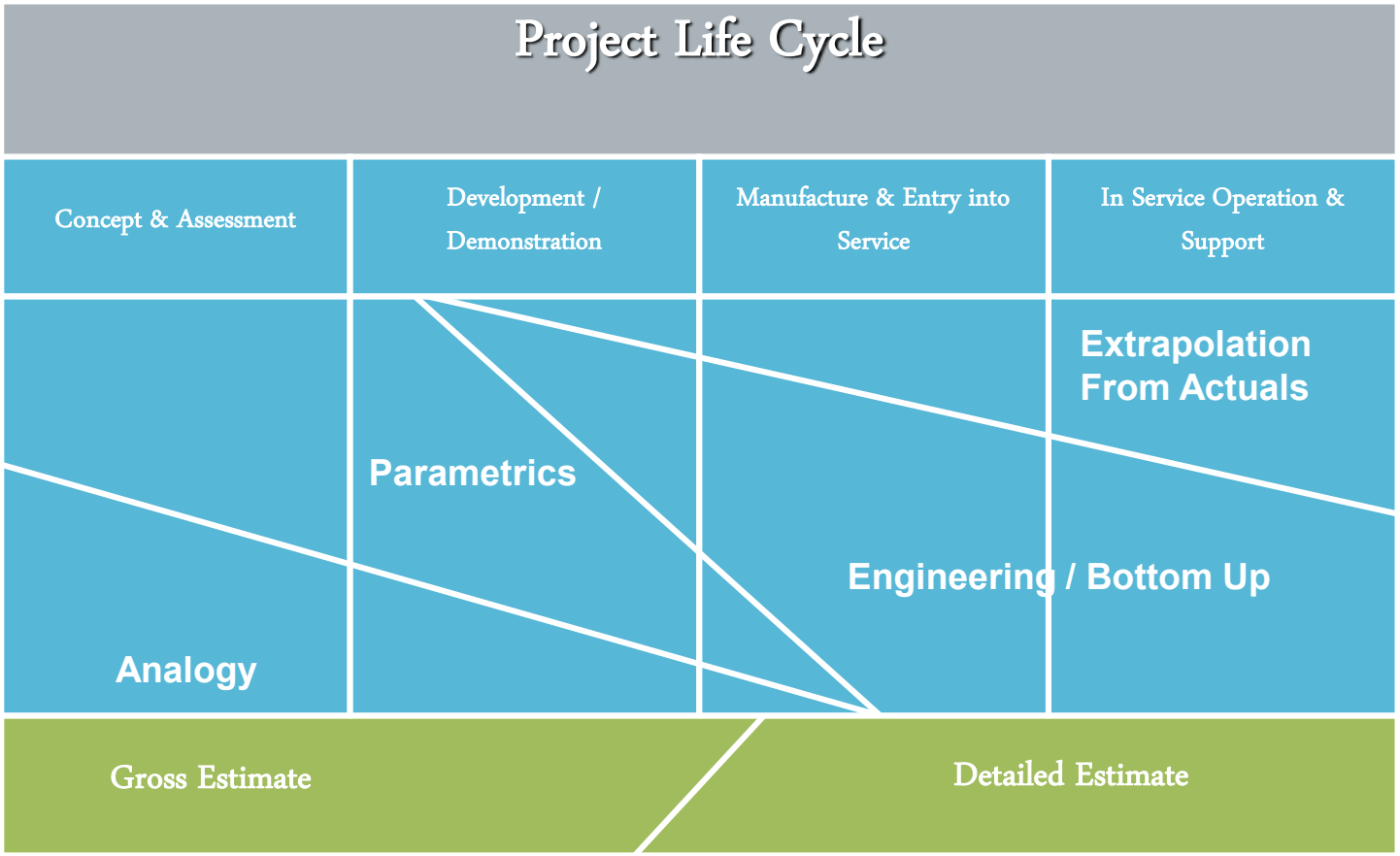
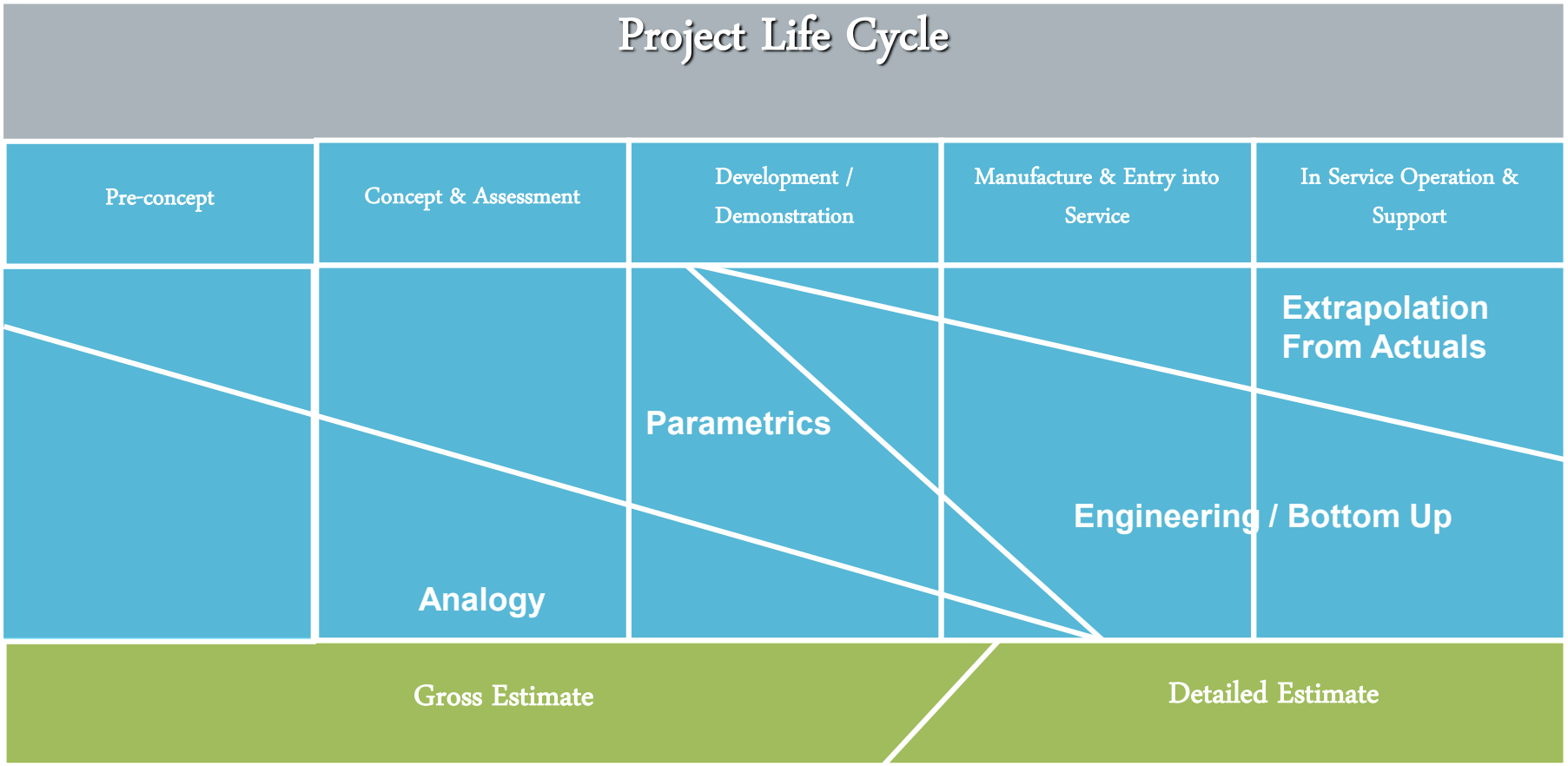
Development of a platform breakdown

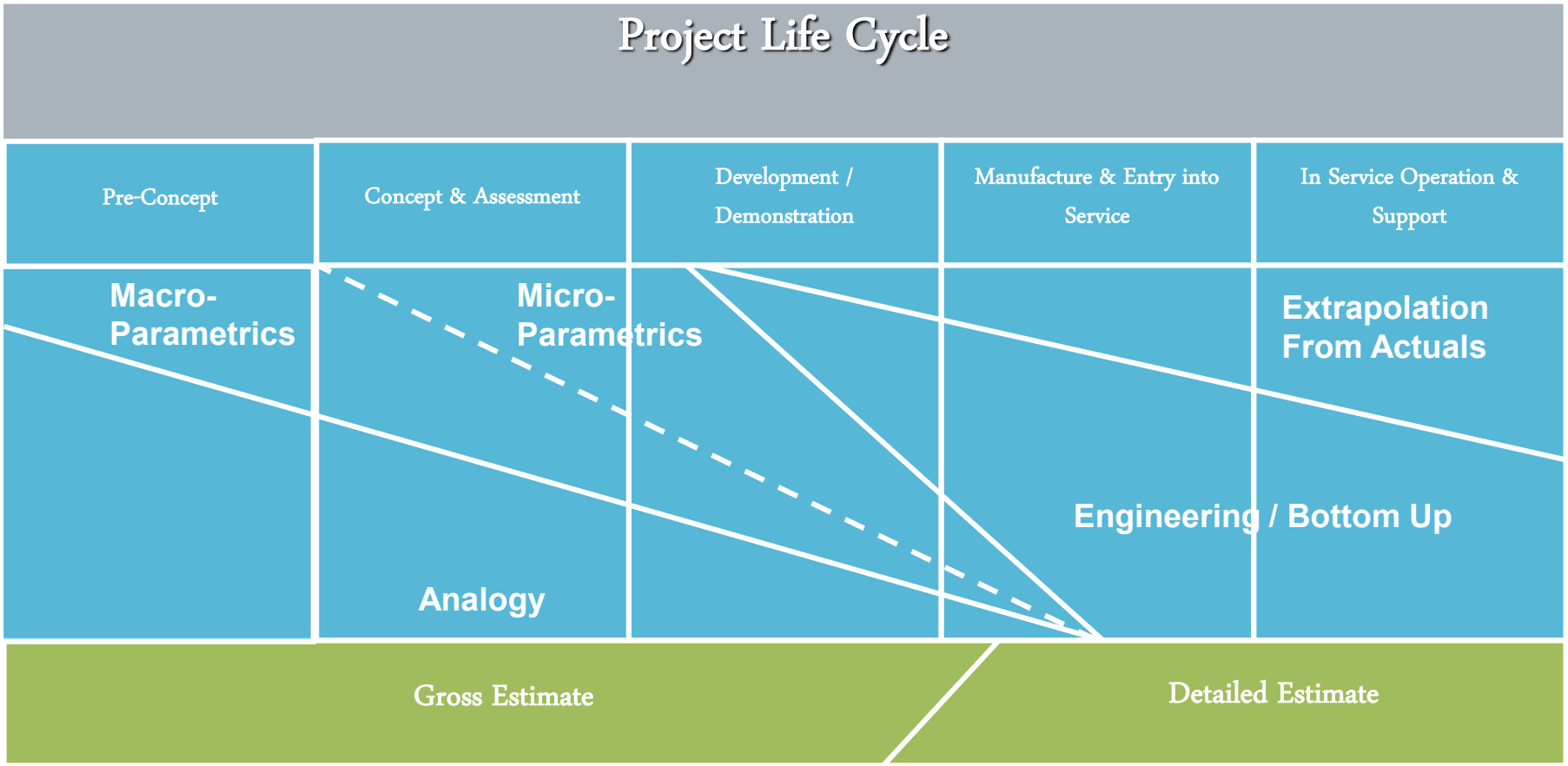


- As a project progresses in time and maturity the level of definition of the platform increases.
- Initially, there are multiple concepts which are competing to fill the gap
- Ultimately, there is a details Bill of Material which defines the complete system

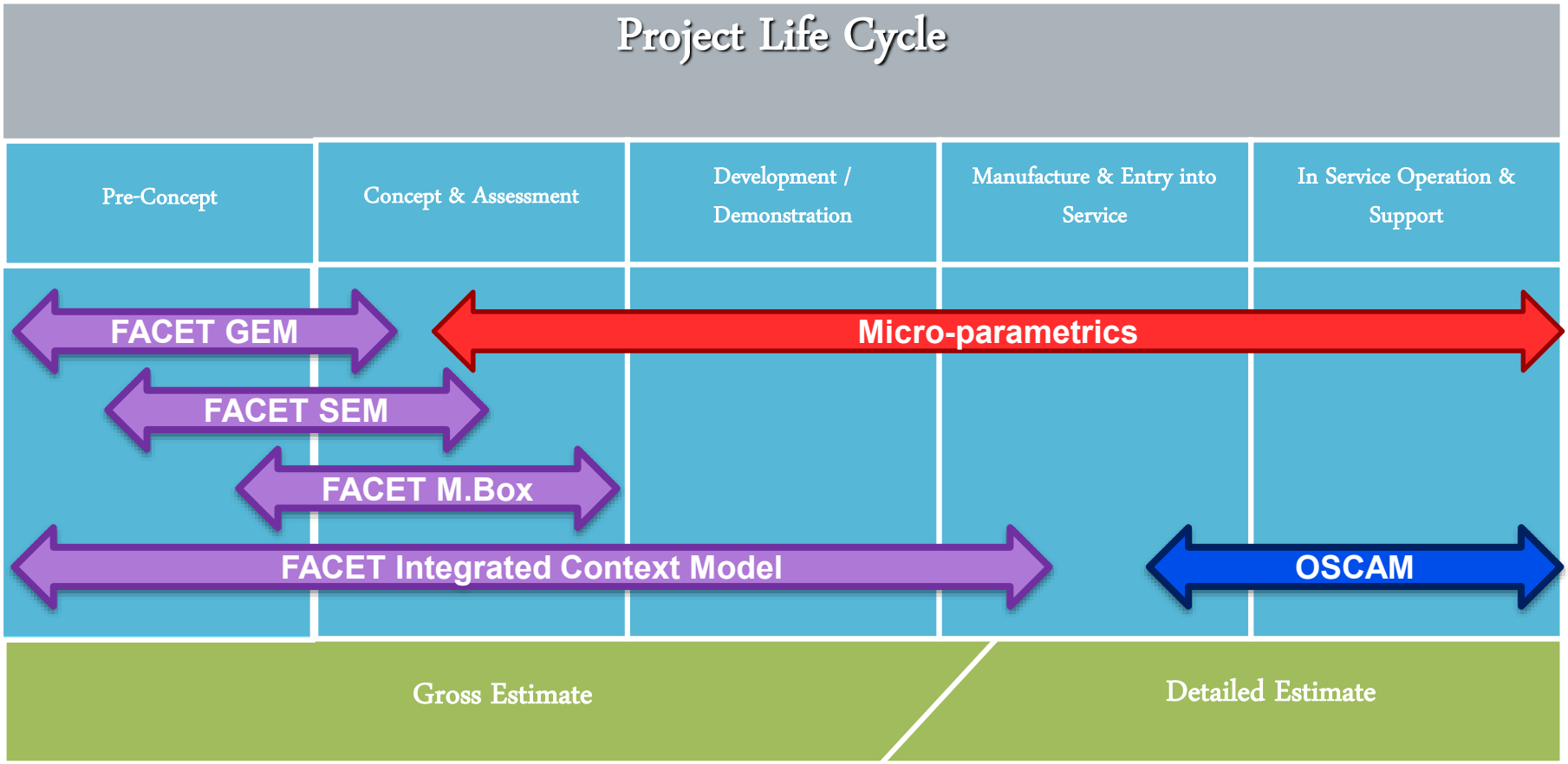


Source: International Cost Estimating and Analysis Association (ICEAA) Book of Knowledge



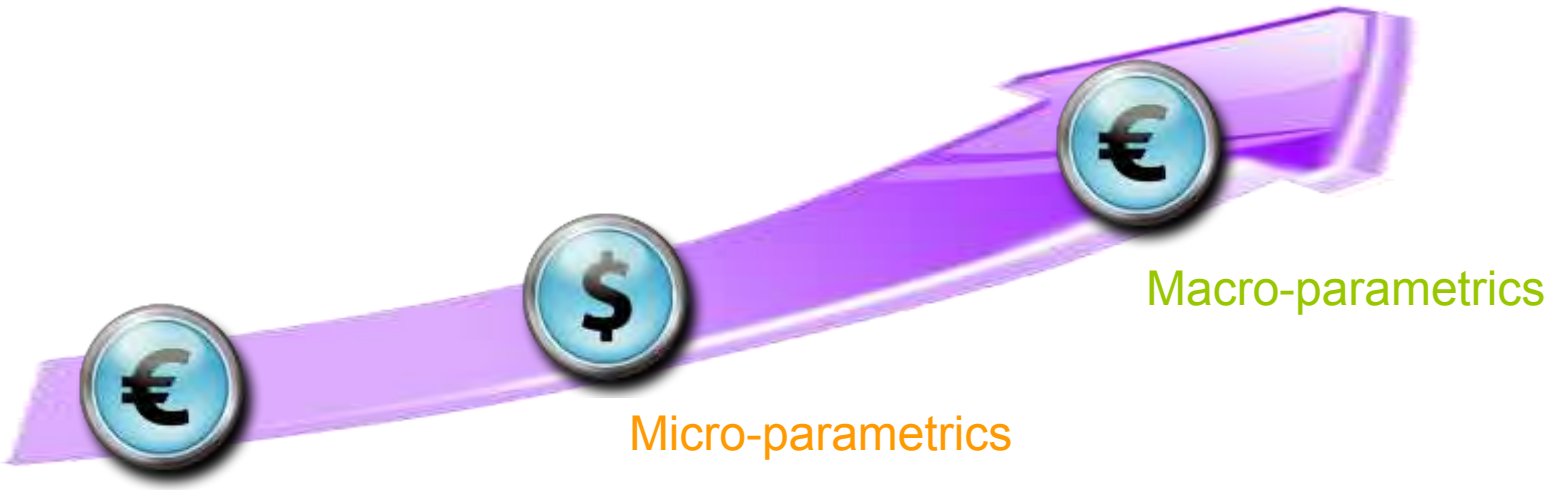


Cost Modelling Capability - Tools for the task



Parametrics - Continuum of Complexity

Increasing Complexity of Method / Relationship



Parametrics – are all models the same?

- Macro-parametrics – the application of a parametric model at the whole system level (e.g. FACET). Considers the big picture, with few cost drivers, but compromises the detail results.
- Micro-parametrics – the focus of parametrics at a lower level than system level (e.g. PRICE, SEER). Considers the system as a number of technologies; more cost drivers are required, but tolerance of the estimate is increased.
- Cost Estimating Relationships (CER) – the lowest level of mathematical algorithm, a single component of a parametric model (e.g. shipping x cost per container). Considers the services or units using a simple expression.

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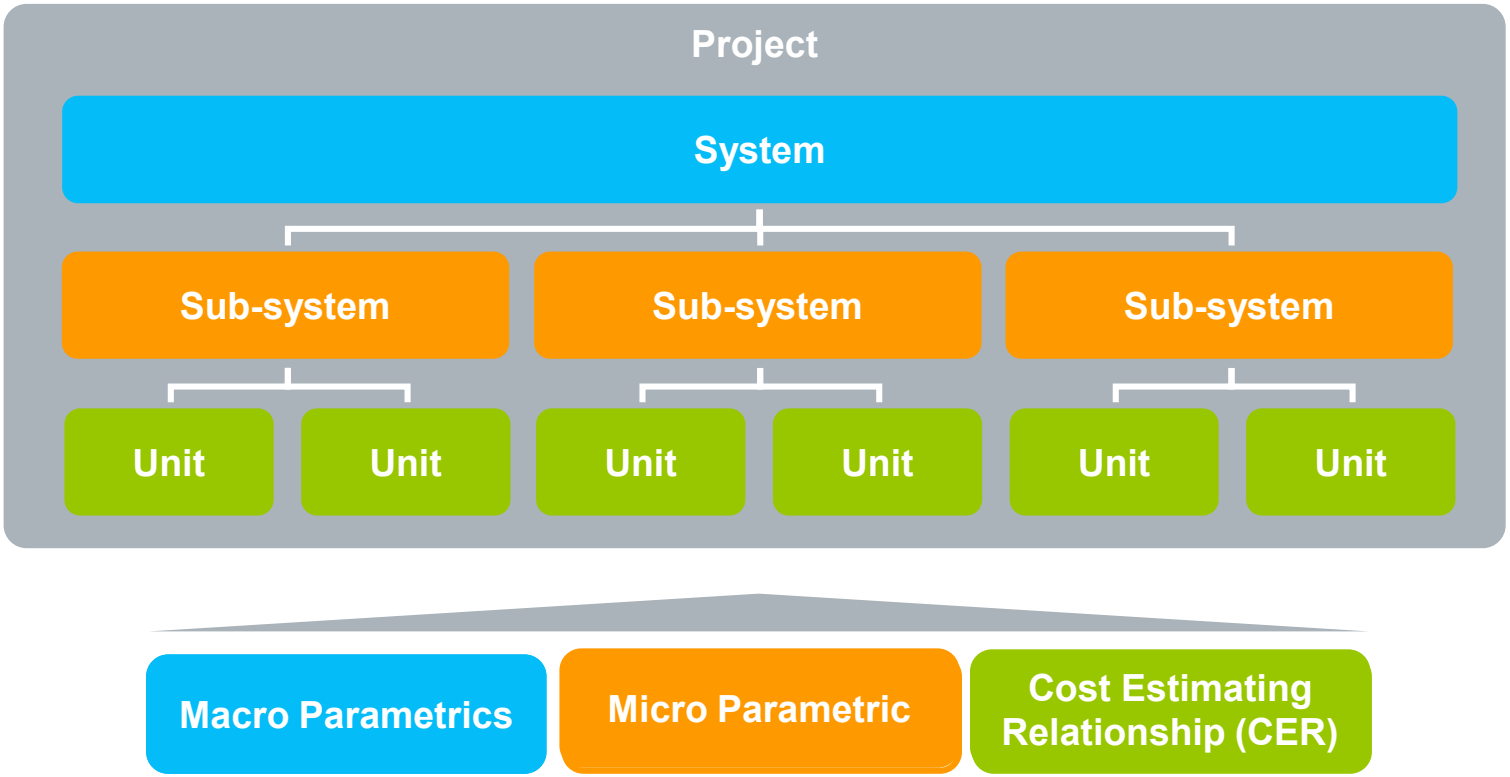
Parametrics – the right model at the right level

- QinetiQ applies the right estimating methodology at the right level…..



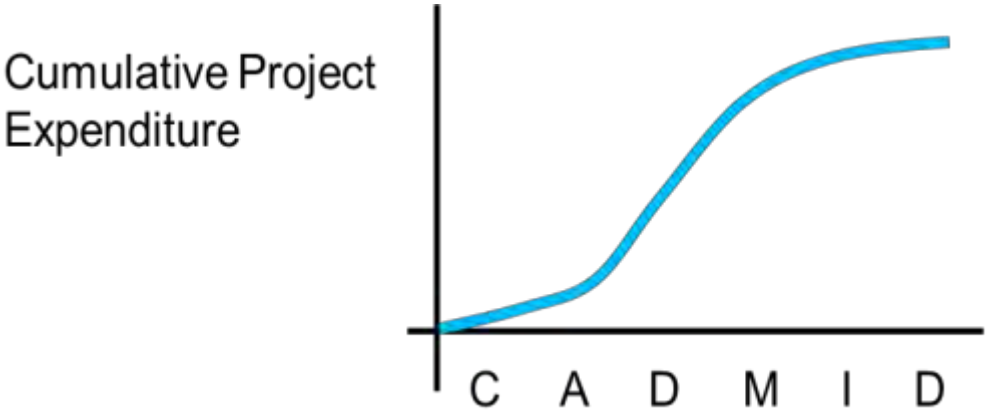
3.

Family of Advanced Cost Estimating Tools (FACET)

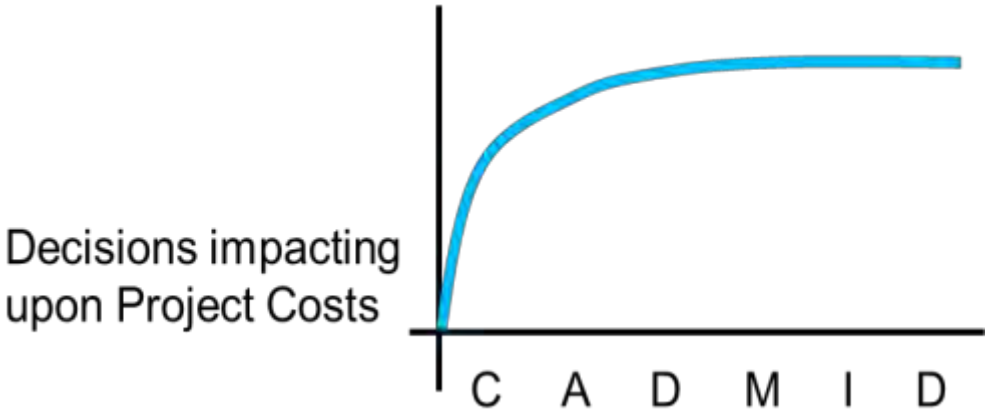
– macro-parametrics

Early Estimates set the budget!

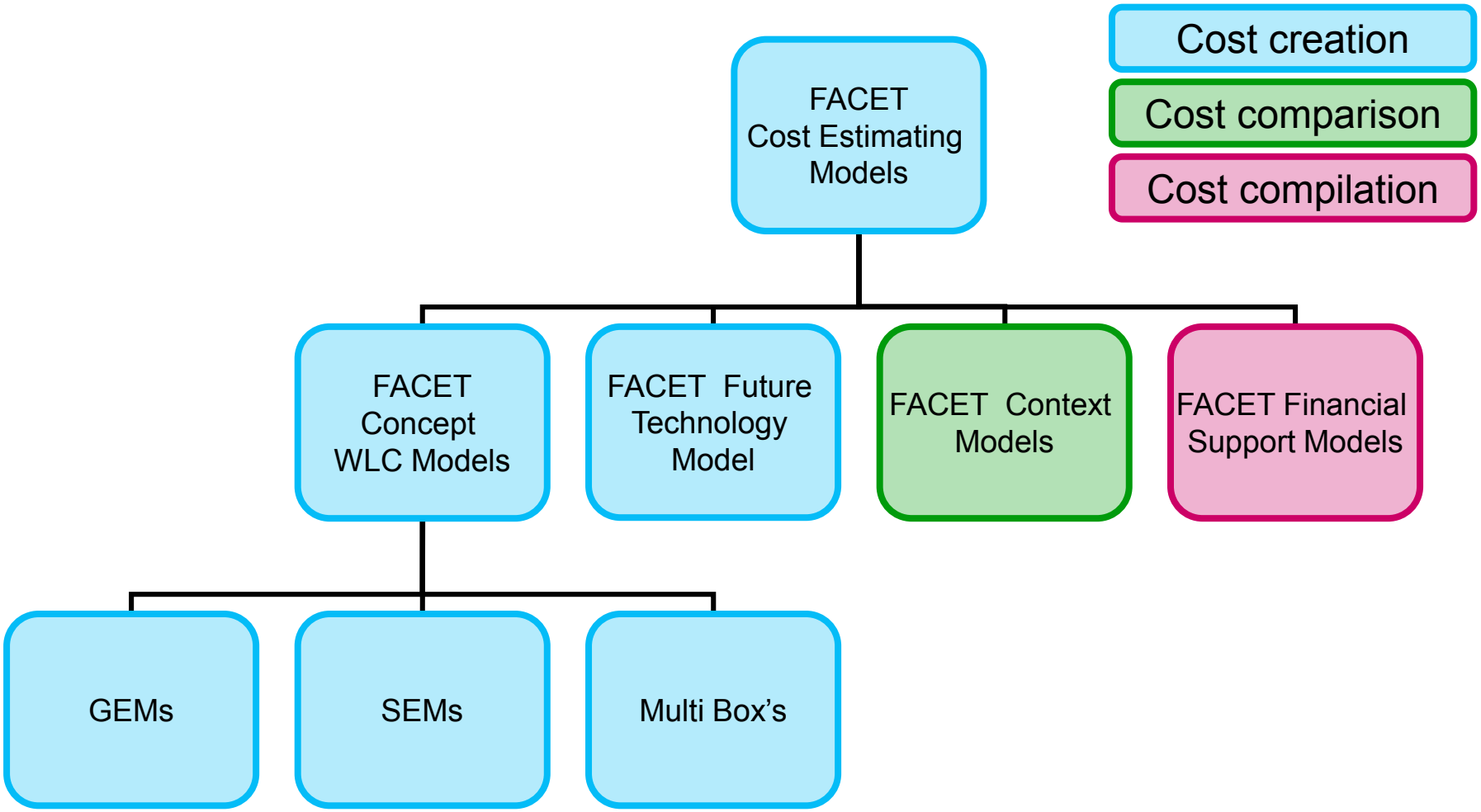
During this period of the project life there is the **opportunity** for projects to influence the Whole Life Cost at **minimum** expense to the overall project



The methodology adopted for the FACET models gives accurate **unbiased** costs for a wide range of weapon systems at the **earliest** (concept) stages of projects.

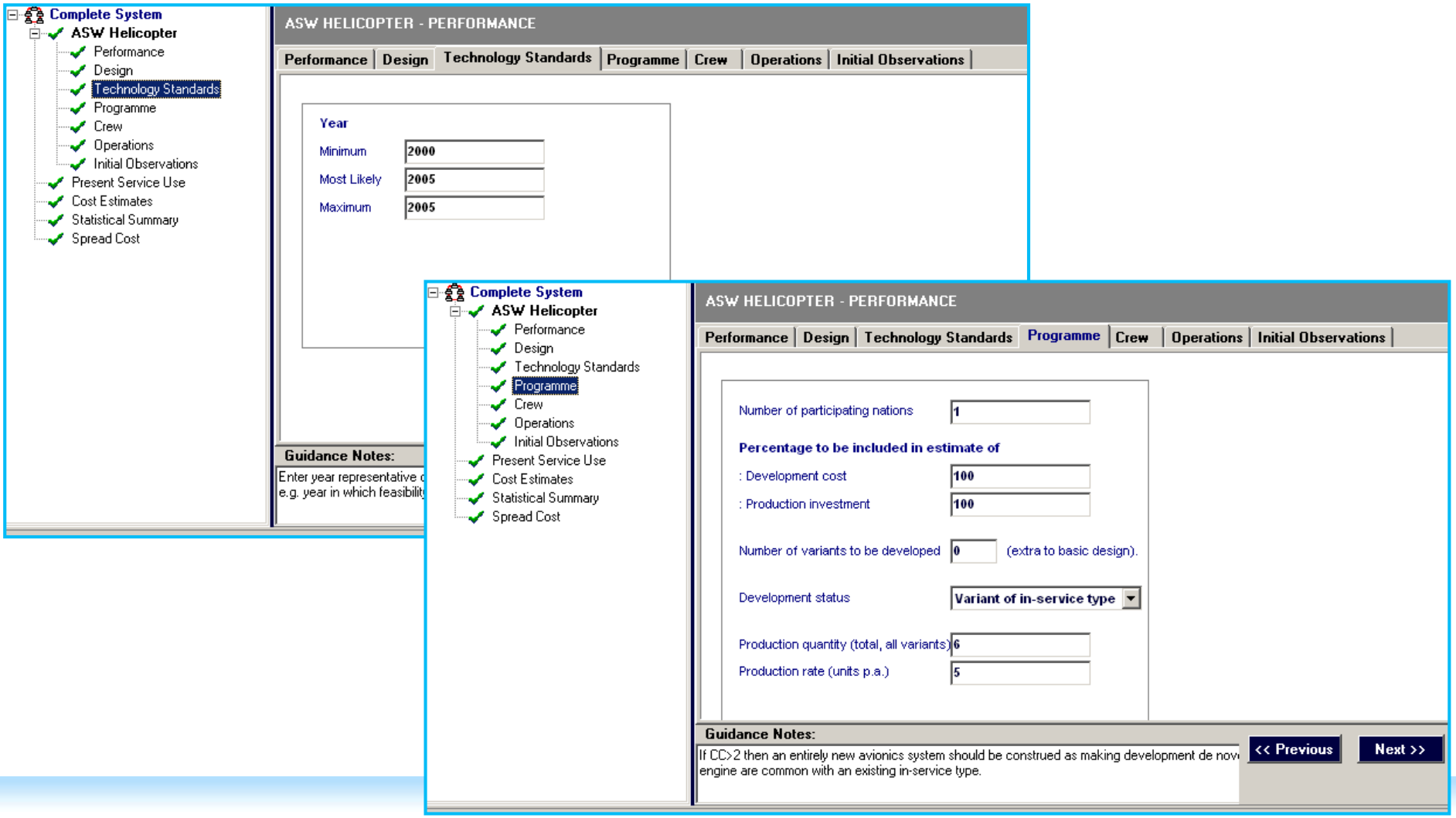


FACET Model Hierarchy



FACET WLC Models : Input Screens

Cost creation



FACET WLC Models : Results Screens

Cost creation

Cost Estimates | Review System

Study Name Fghter Aircraft Study

Economic Conditions £ / 2008 / Million

Acquisition Costs

Development	4,672.17
Production	6,714.03
Total Acquisition	11,386.21

In-Service Costs

Non Crew	33,611.57
Crew	408.33
Total In-Service	34,019.91

Total LCC 45,406.11

Unit Production Cost (Units) £44,760,227

NOTES:

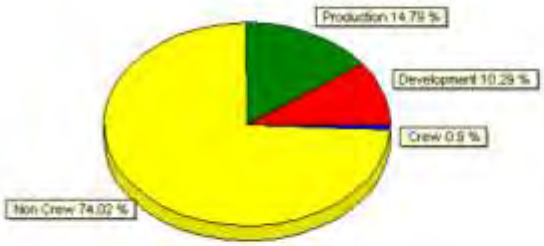
Text Visual

Cost Estimates | Review System

Study Name Fghter Aircraft Study

Economic Conditions £ / 2008 / Million

Breakdown of Cost Estimates



Text Visual Percentage Value Breakdown

Cost Estimates | Review System

Summary of system characteristics

Serial	Component	Quantity
System		
1	Fighter/strike aircraft (exist	1

Economic Conditions £ / 2008 / Million

Overall programme

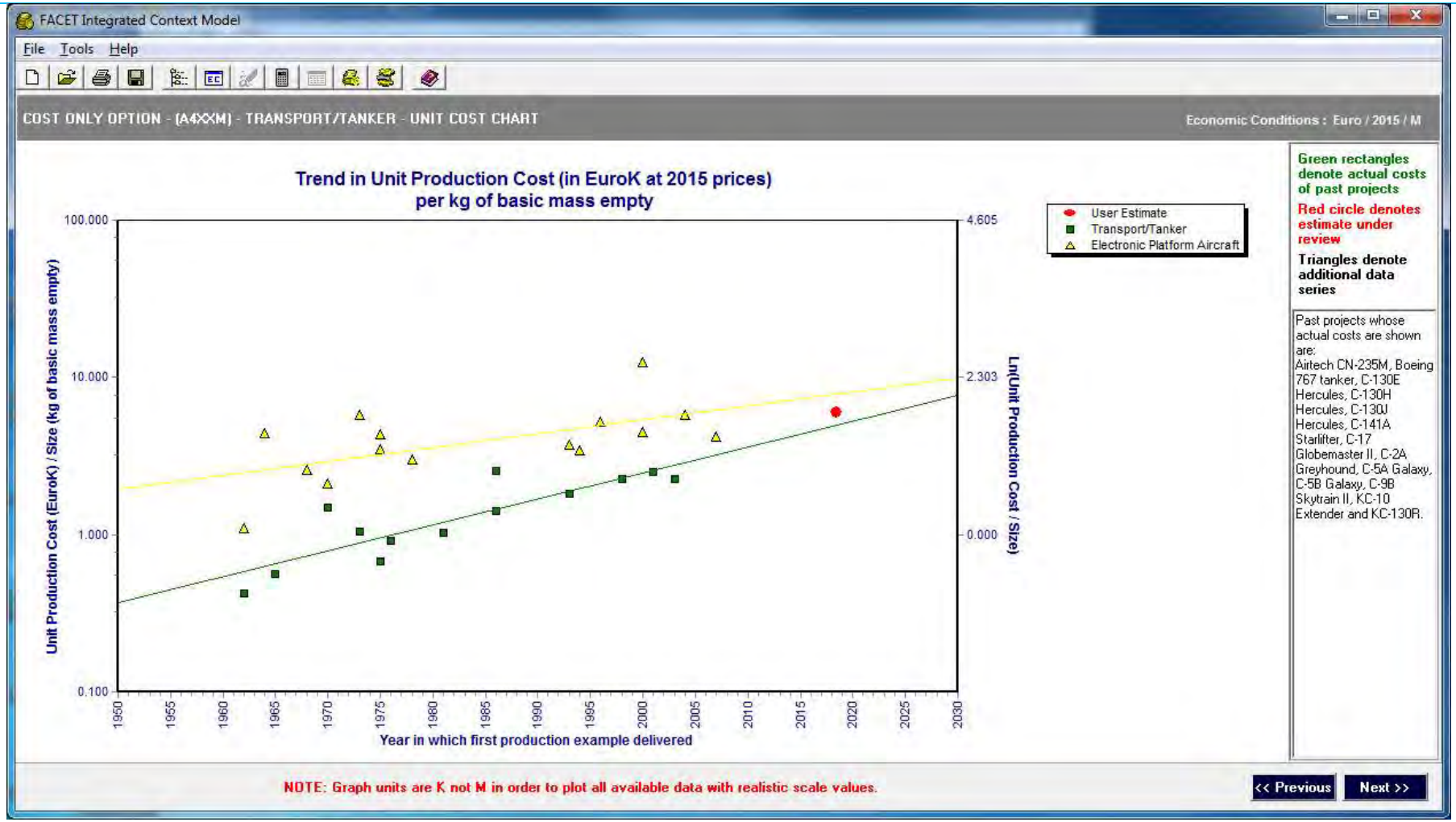
Production quantity	150.00
Production rate p.a.	2.50
Develop time, yr (Mean)	14.32
(SE)	2.66
Total Crew	
Pilots (Mean)	2
Other crew (Mean)	0

Details of Fighter/strike aircraft (existing engine)

	Mean Values	SE
Payload, kg	316.67	92.04
Basic mass empty, kg	2,089.89	306.57

FACET Cost Context Model Output

Cost comparison



The context model provide a rapid evaluation capability of quotation and internal estimates

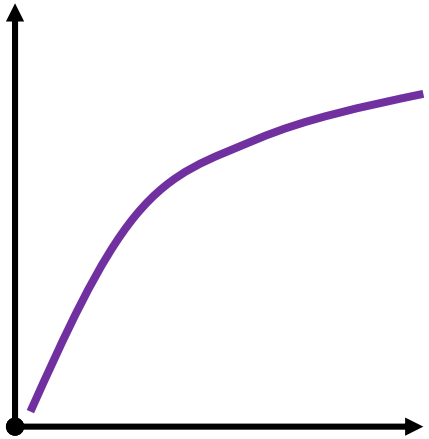
4.

Multi-colinearity

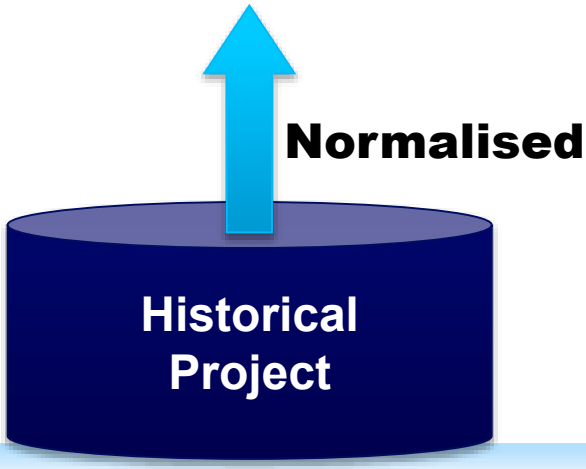
Parametric Cost Modelling

Cost Estimating Relationship (CER)

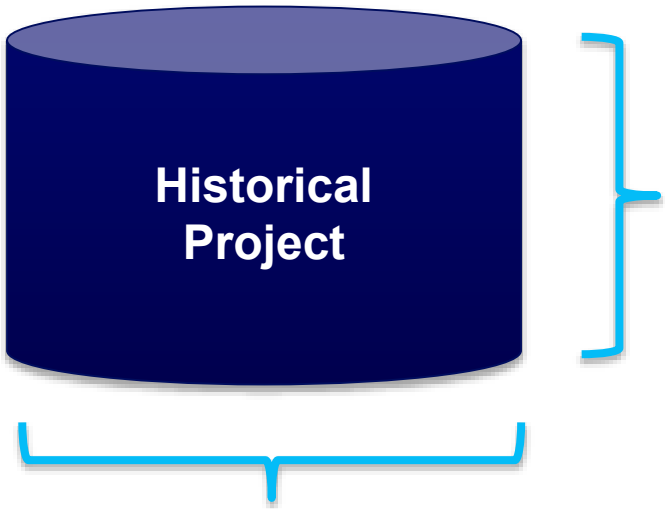
Independent variable
- Design
- Performance



Dependent variable
- Cost
- Schedule
- Performance



One database: two cost research approaches



Micro-parametrics:

- Technology focus
- Single universal model
- Numerous independent parameters to describe the project

Macro-parametrics:

- Platform / System focus
- Numerous platform models
- Few platform specific independent parameters to describe the platform

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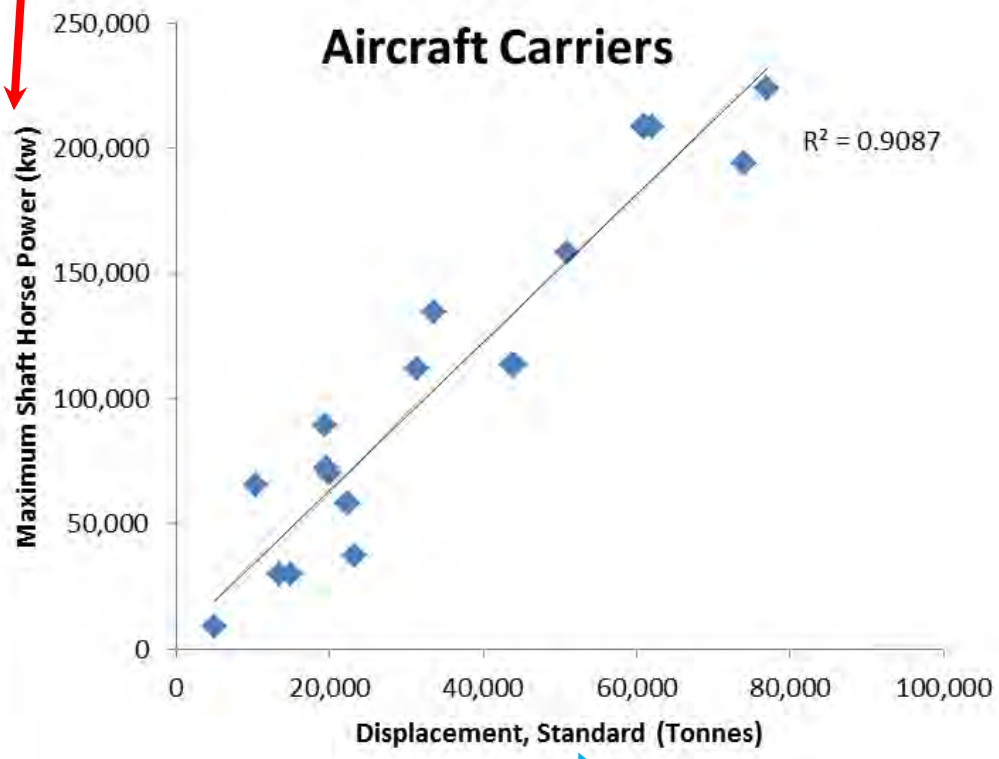
Multi-Colinearity

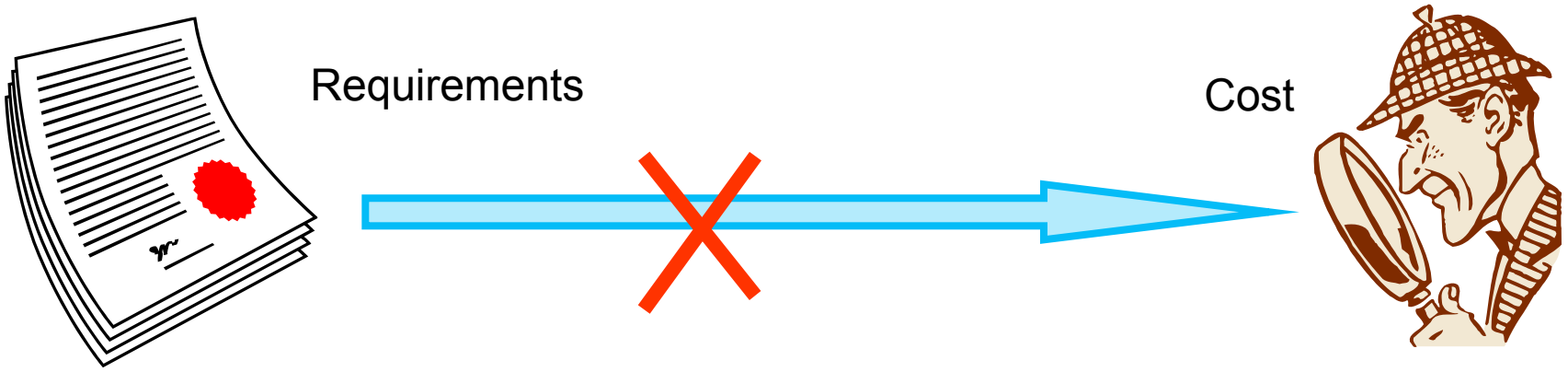
Performance Parameter



- Traditional thinking is that if the variables are correlated you must not use both in the CER.
- If you include one the other is inferred; you can discard one variable.
- FACET uses the Performance parameter as a cross check to ensure that the proposed Design parameter and solution is viable.

Design Parameter

Multi-Colinearity

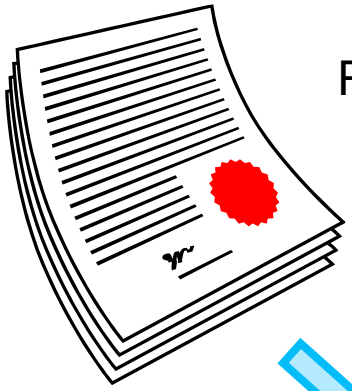


It's not possible to estimate capability or requirements without a design

?

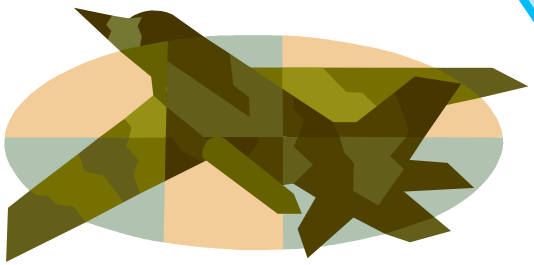
Concept Design

Multi-Colinearity



Requirements

Cost



Concept Design

Therefore we create a concept and estimate it to a high tolerance

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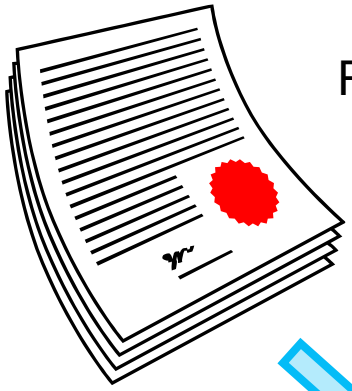
Multi-Colinearity



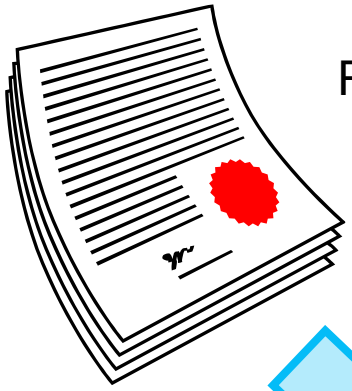
Requirements

Cost

Then discover the design is not the same as the concept?

Final Design

Multi-Colinearity



Requirements

Cost

Final Design

What is required is early relationship between requirements, design and forecast cost

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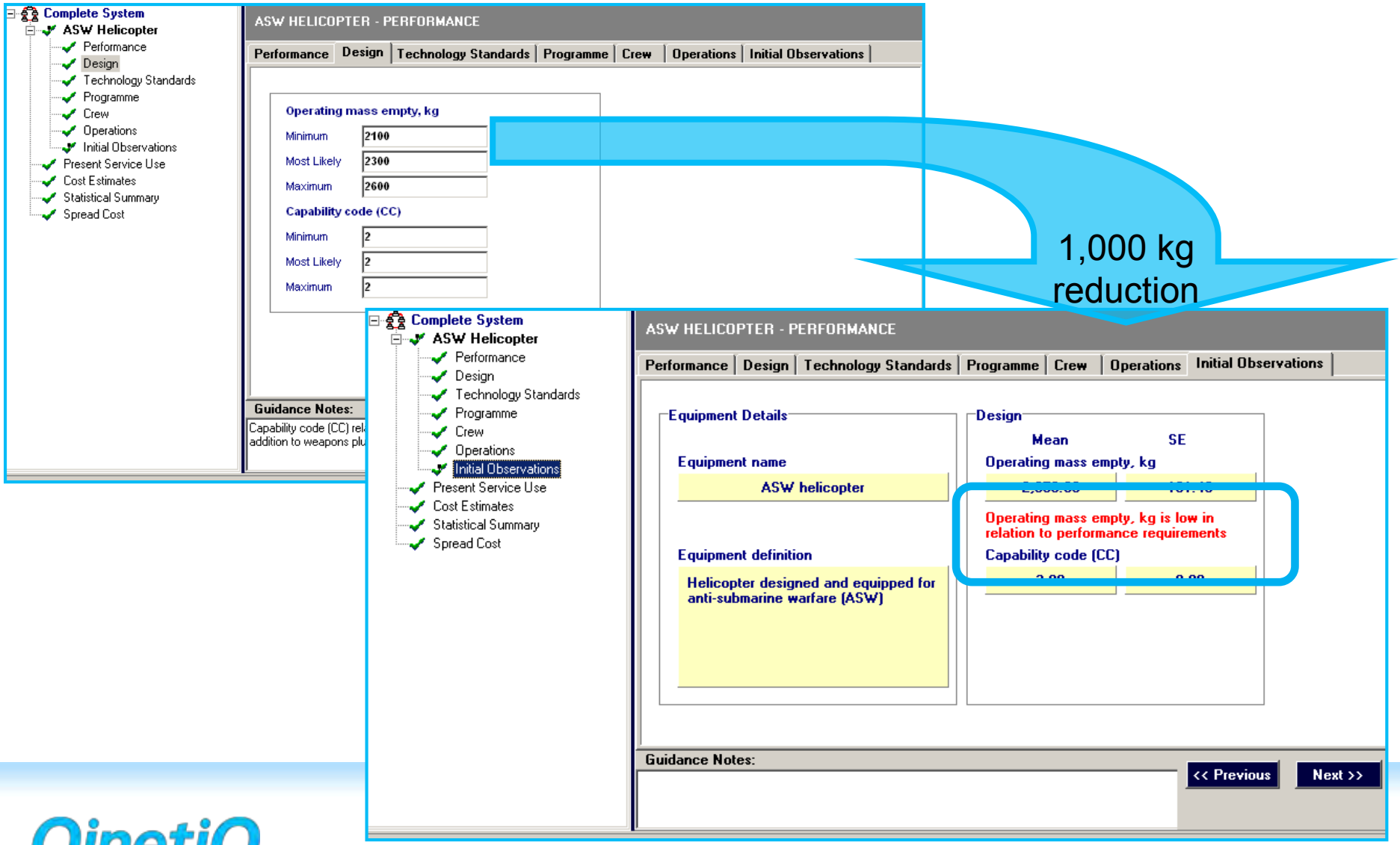
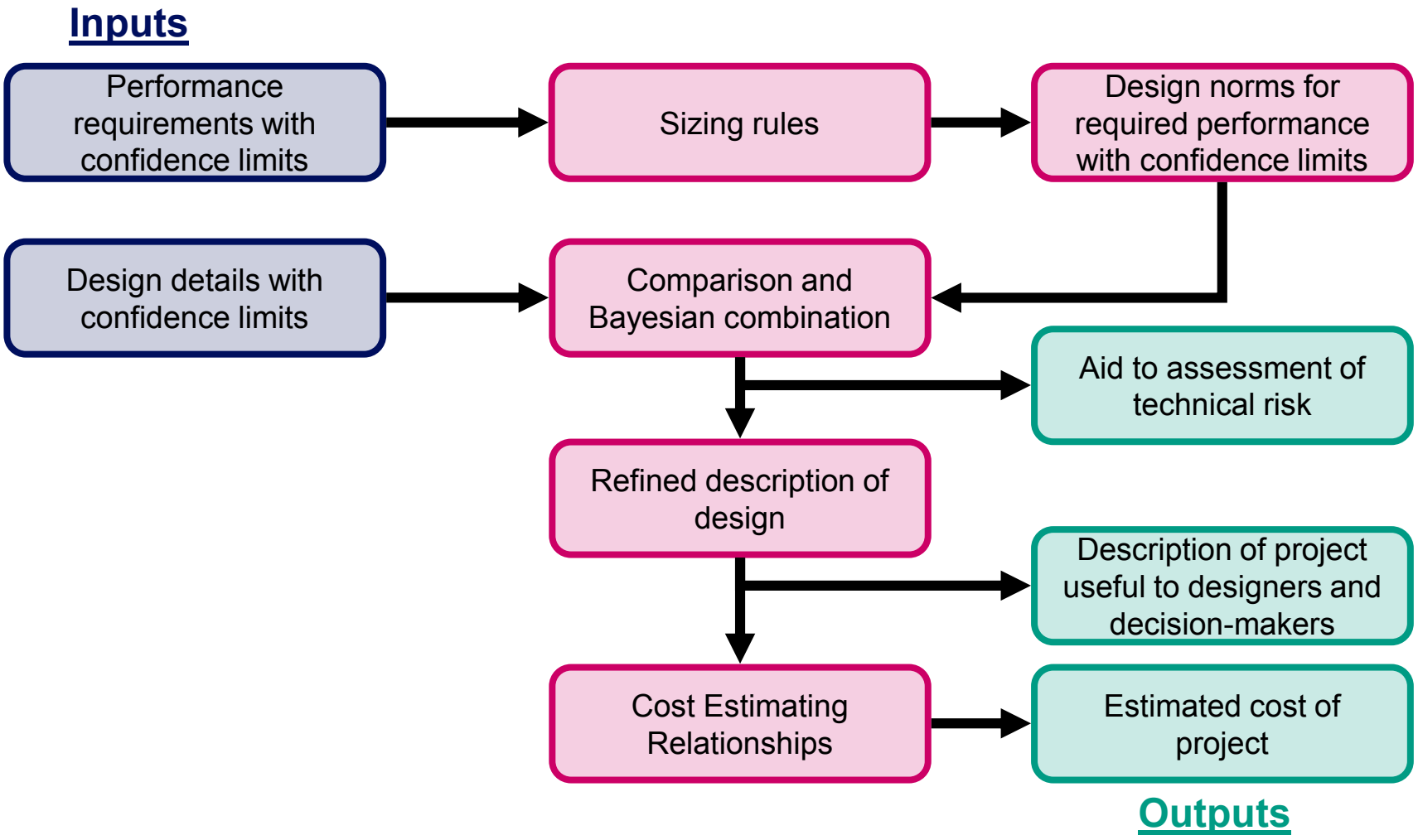
Multi-Colinearity utilised in the FACET Models



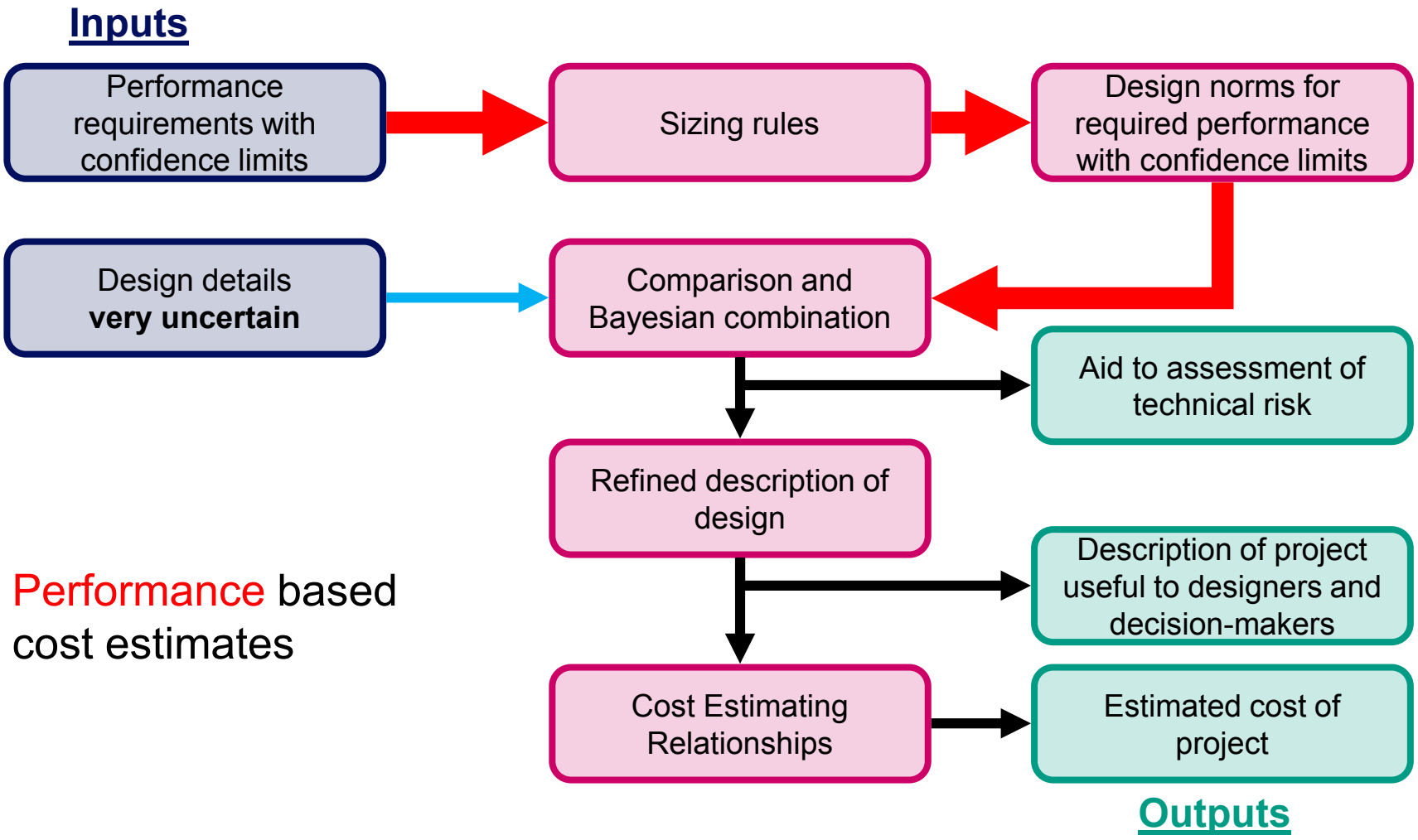
5.

Performance and Design based estimating

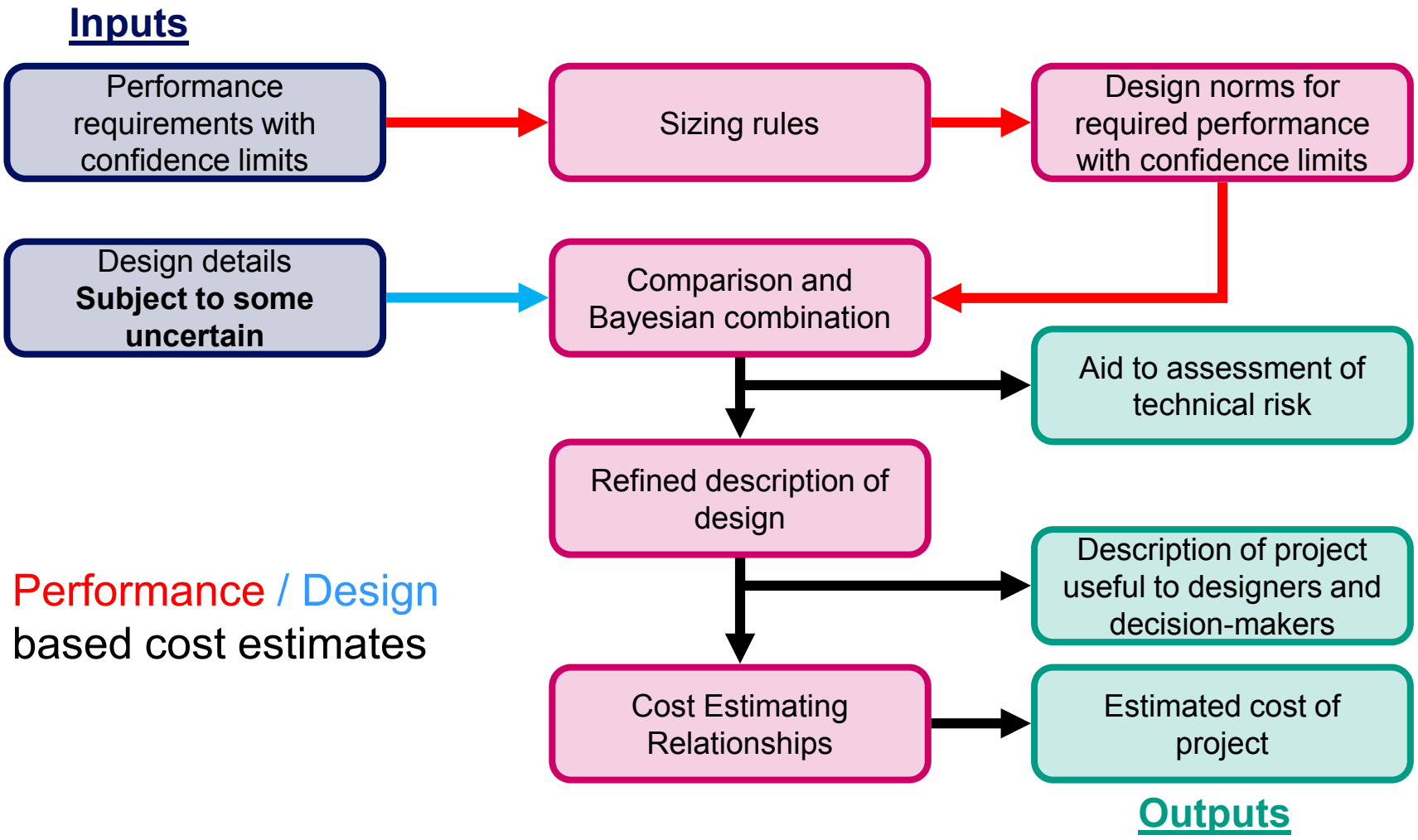
Implementation of a combined performance / design based approach to cost estimating



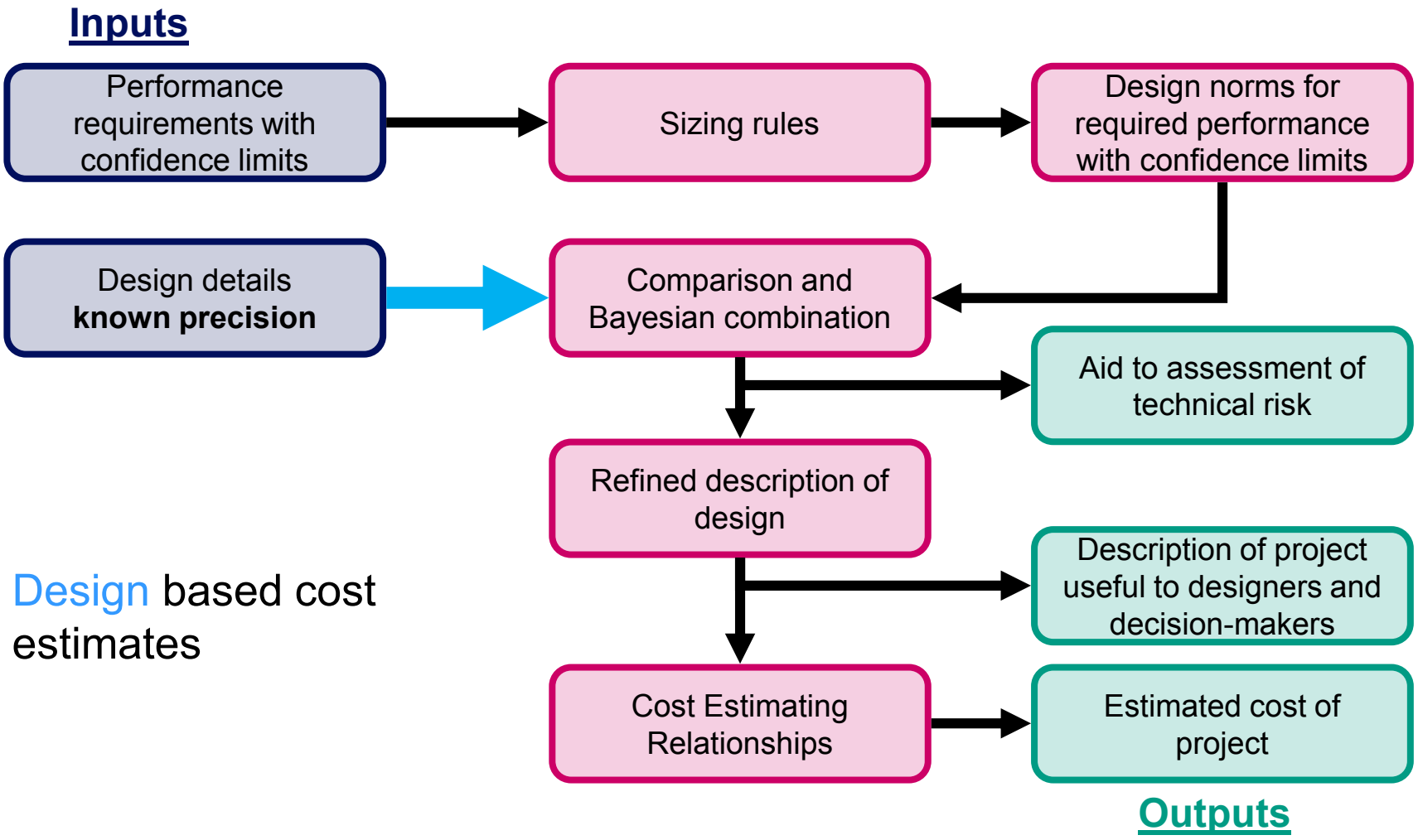
Implementation of a combined performance / design based approach to cost estimating



Implementation of a combined performance / design based approach to cost estimating

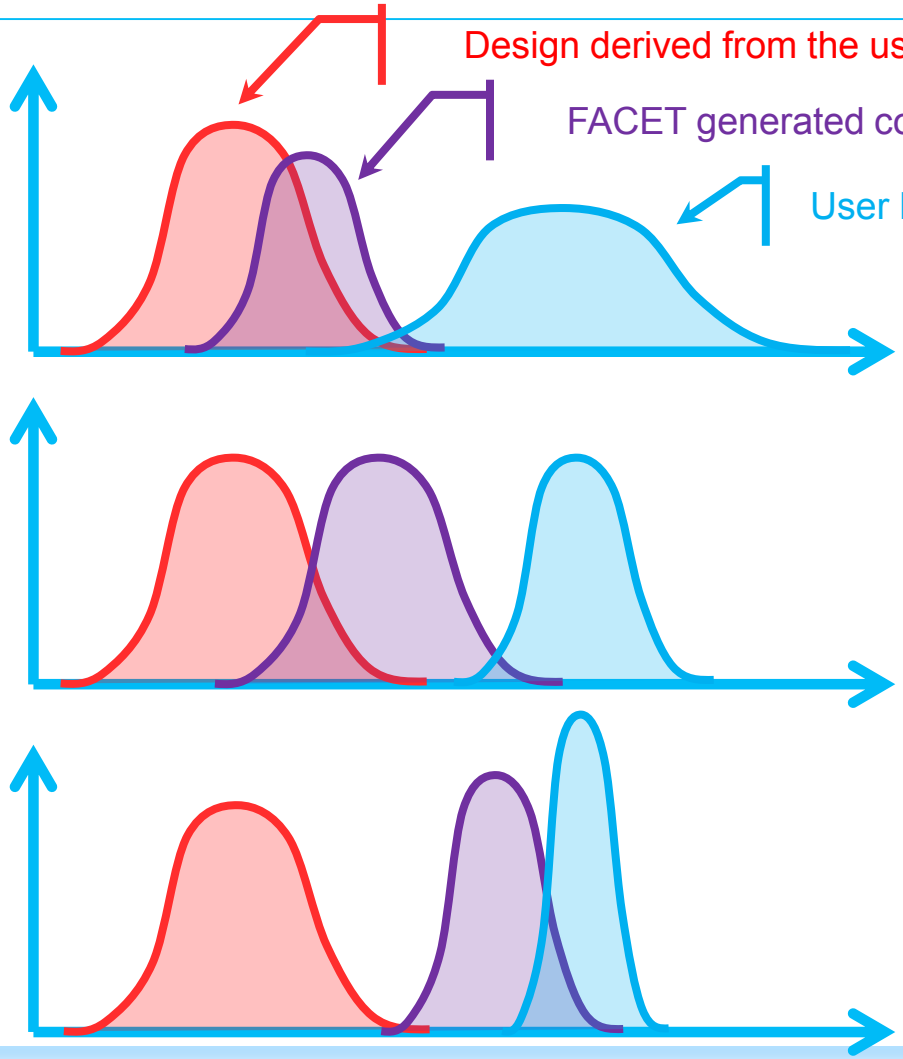


Implementation of a combined performance / design based approach to cost estimating



Design based cost estimates

Using Bayesian to merge the user inputs



Performance based cost estimates

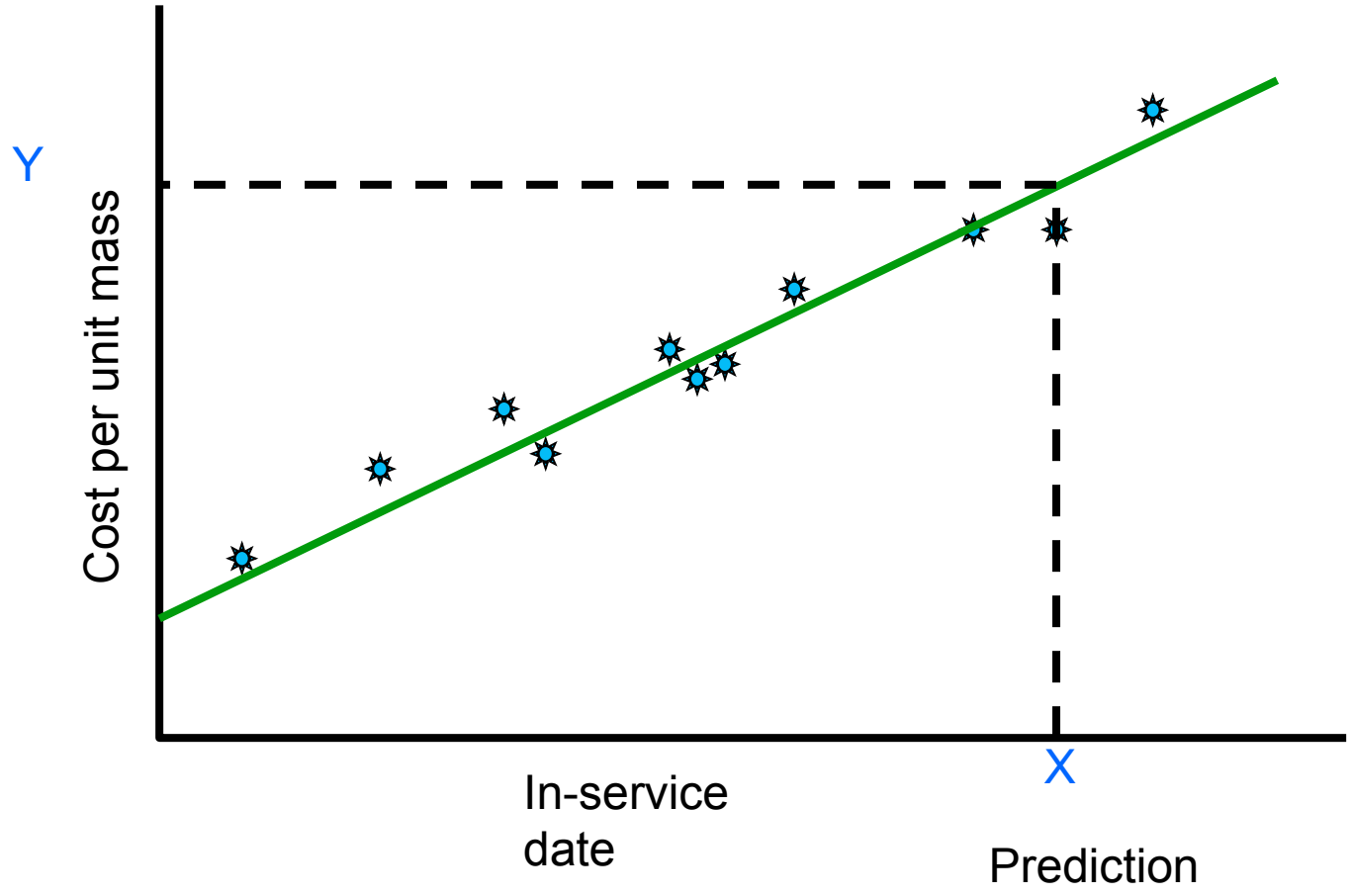
Performance / Design based cost estimates

Design based cost estimates

6.

Data and CER uncertainty

Deterministic prediction for X



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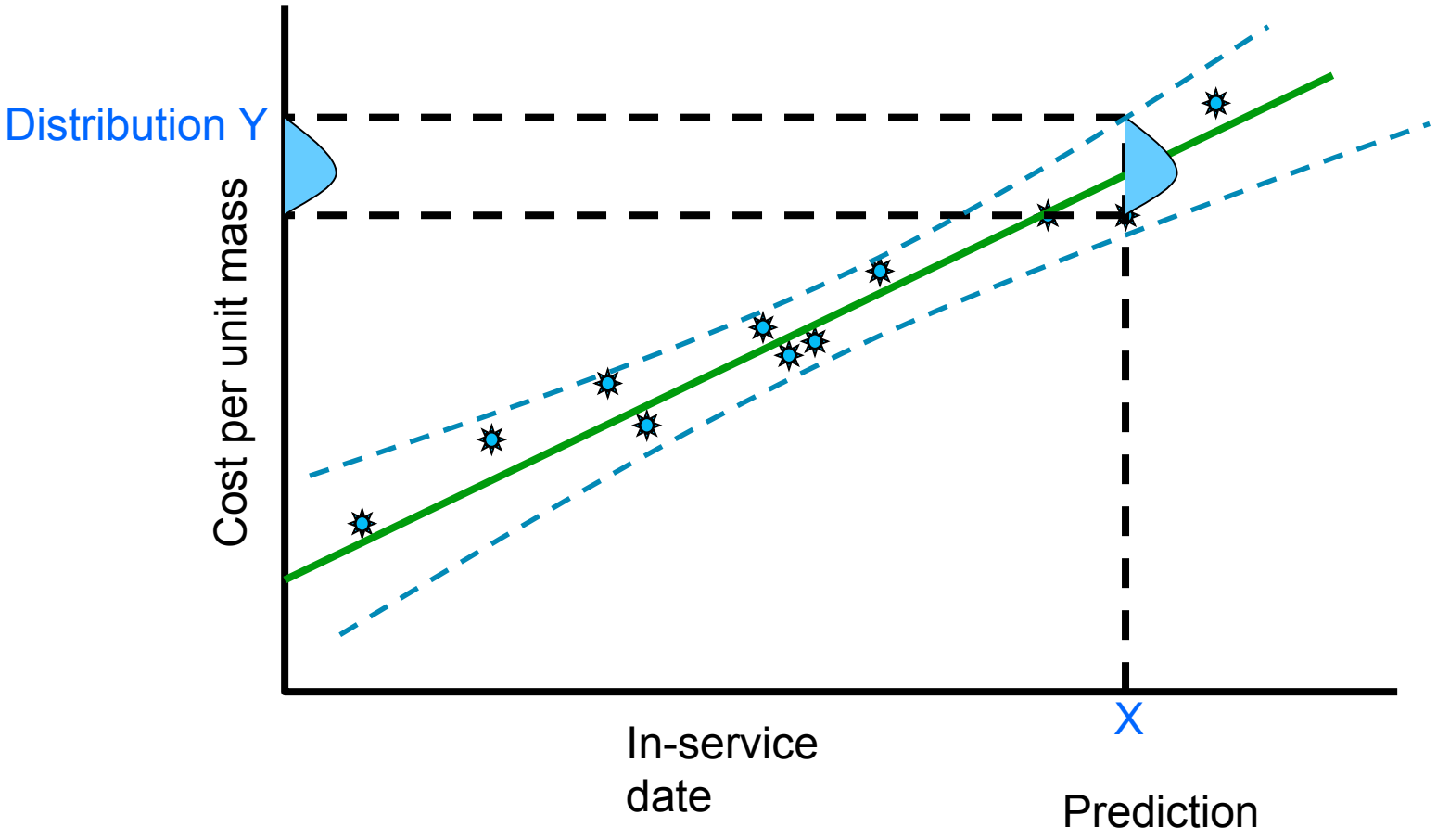
Recognising the CER error



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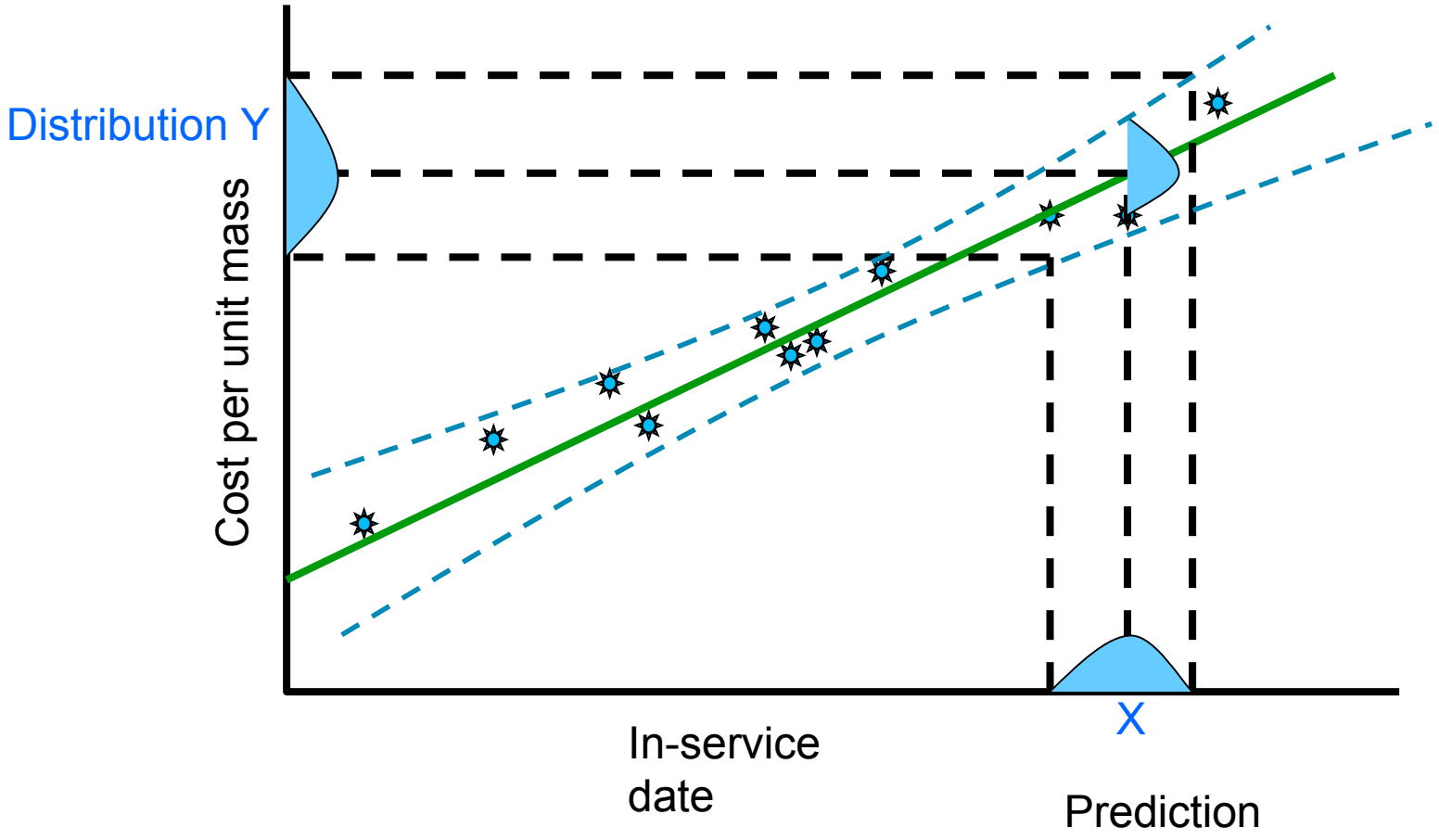
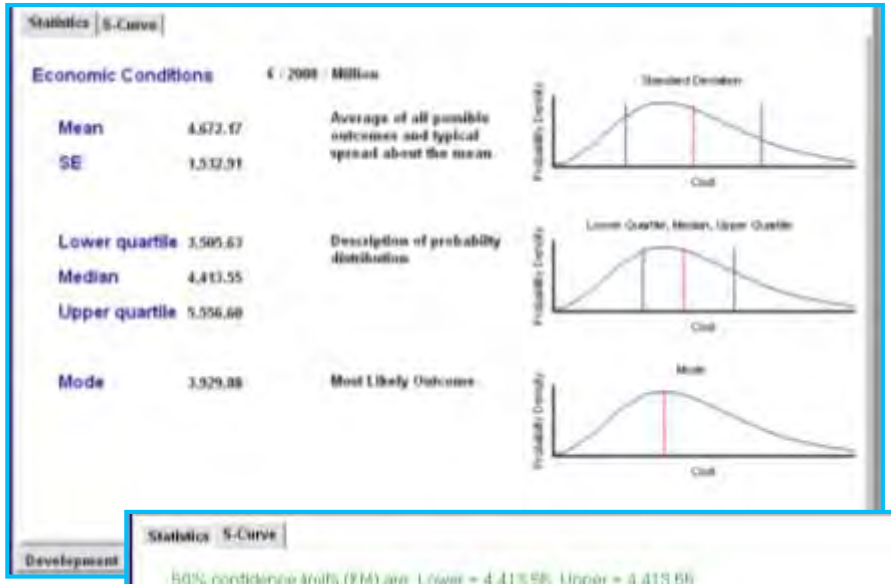
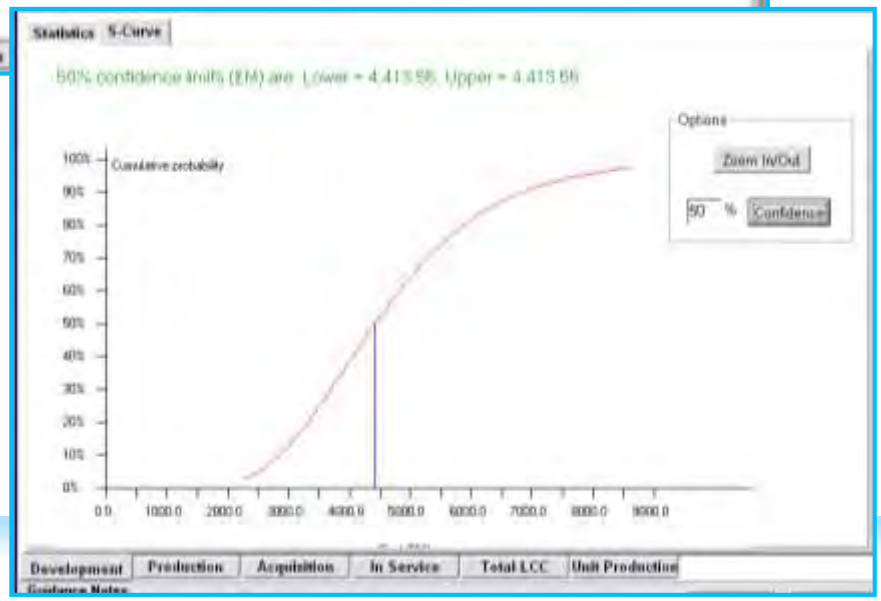
Recognising the compound error of CER and input



FACET Models: Output Statistical Screen

- Output as an “S-Curve” taking into consideration the uncertainty around the input values and the algorithm.
- Confidence percentile value selected by the user for all elements of the whole life cost output.





7.

Summary

Conclusion

- Marco-parametric estimating is useful early in an aerospace project and for independent cost estimating (ICE).
- Don't ignore correlated independent variables due to multi-colinearity; they can be used as a cross check of the parametric inputs.
- FACET is a macro-parametric cost model which seamlessly migrates from performance-based to design-based cost forecasting.
- It is possible to combine the uncertainty in the algorithm and the uncertainty of the inputs parameters, but beware that the outputs will correctly have a large tolerance.

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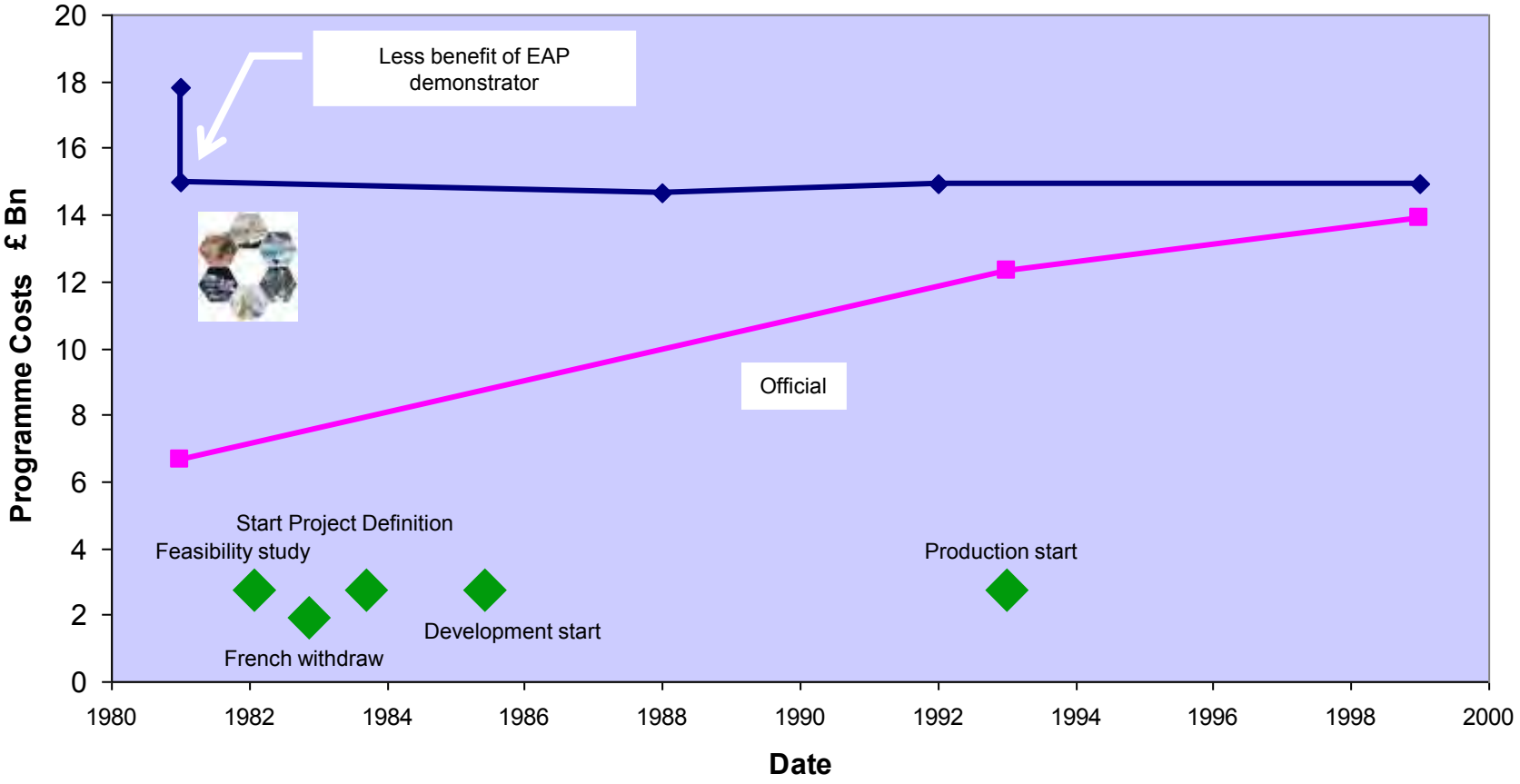
Eurofighter Development Costs

Less than 8% difference between FACET and last official programme cost

110% cost growth between first and last official programme costs



Charles De Gaulle; Programme Costs

Less than 2% difference between FACET and last official programme cost

28% cost growth between first and last official programme costs

FFr 15.6 Bn First published estimate of the Programme cost April 1992

FFr 20.38 Bn Estimated Programme cost. Using FACET and only technical data available in 1992

FFr 17.2Bn

FFr 18.8Bn

Official

FFr 20 Bn Last Programme cost estimate Sept 2000

Programme authorised

First block

First steel cut

Official Launch

Start of sea trials

Commissioned

Programme Costs FFr Bn

0 5 10 15 20 25

1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002

Date

Any Questions?

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