SCHOOL OF ENGINEERING | WEEK 4

Engineering Project Management

Cost Estimation

Introduction and financial resources



Photo: Sadara Project, Saudi Arabia. Credit: The Chemical Engineer

Today

WEEK 4

Cost estimation: introduction and financial resources

01

Estimating principles

Forecasts, objectives and the estimating process

02

Accuracy through the project

Estimate stages, accuracy and bias

03

Financial resources

Expenditure, income, liability, earning, retention

04

Building the estimate

Cost elements, data, Holyrood and methods

01

Estimating principles

What an estimate is, and why clients want certainty

What is an estimate?

es·ti·mate

(ĕs'tə-māt')

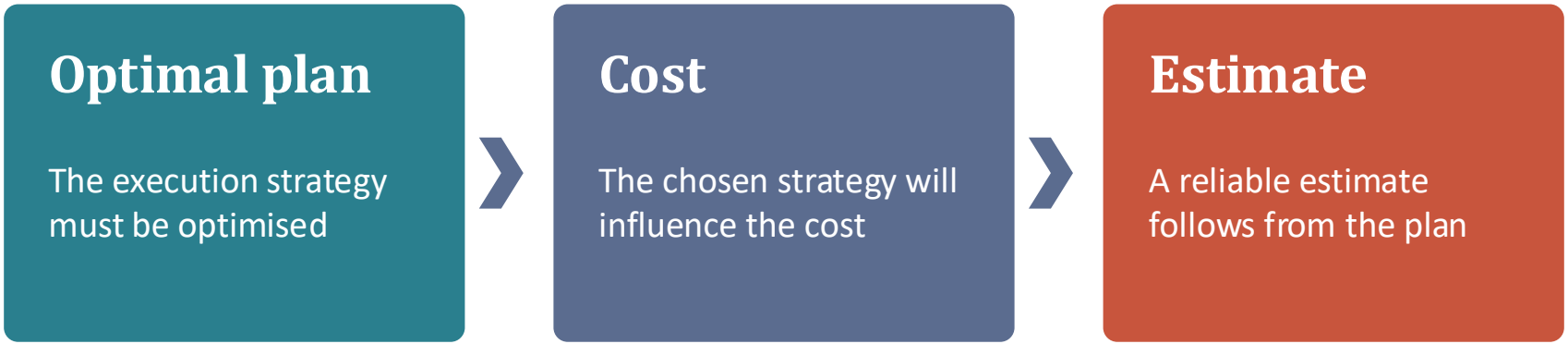
verb

TO ESTIMATE IS…

To calculate **approximately** the amount, extent, magnitude, position, or value of something.

Planning and estimating go together

A project cannot be estimated before it is planned.



Planning and estimating are done together, not one after the other.

“Fixed in time and cost”

Forecasts, not certainties

Both planning and estimating produce what are essentially forecasts.

What clients want

Certainty: a known end date with a known cost.

Is this realistic?



Mark Wild – current CEO of HS2

Lesson 1: “Fixed end-dates are deadly”

Watch on YouTube (https://www.youtube.com/watch?v=fTZ_L2Etq48)

Objectives of cost estimating

To define, as accurately as possible, the realistic cost of executing an activity – also called cost planning.

An estimate is used for:



Comparing alternative technical solutions



Identifying financial commitment



A basis for tendering



A yardstick against which performance can be measured

The estimating process varies

Estimating the total cost of a project can be variable. It depends on:



The type of project

Civil, offshore, process etc.



Who is estimating

Client, contractor, sub-contractor etc.



The stage of the project

Concept, design, pre-tender etc.

Next week: different methods suit different stages – and give different accuracies.

The estimating process: stages

1 Today

Consideration of cost & finance

2 Today

Identifying elements of cost

3 Today

Determining cost data

4 Methods next week

Applying the data (estimating methods)

5 Contractors only

Conversion of estimate into a tender bid

6

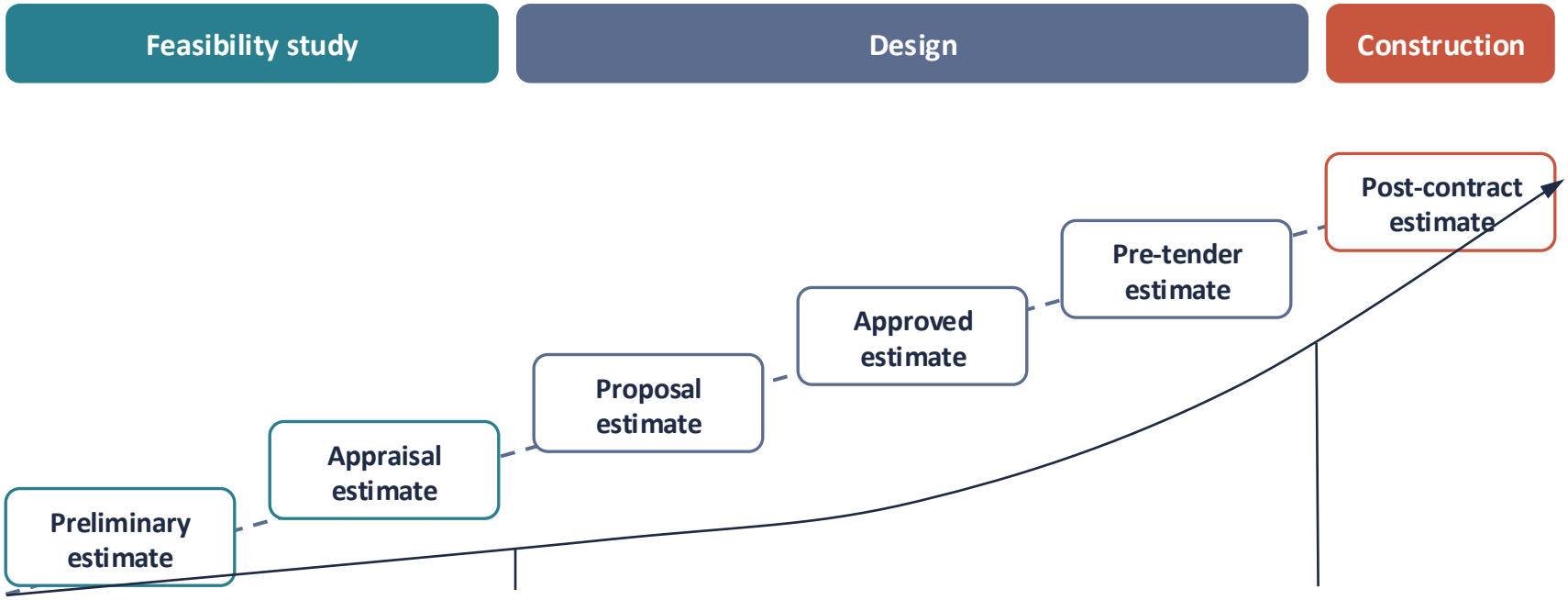
Consideration of other factors

02

Accuracy through the project

How estimates change from feasibility to final account

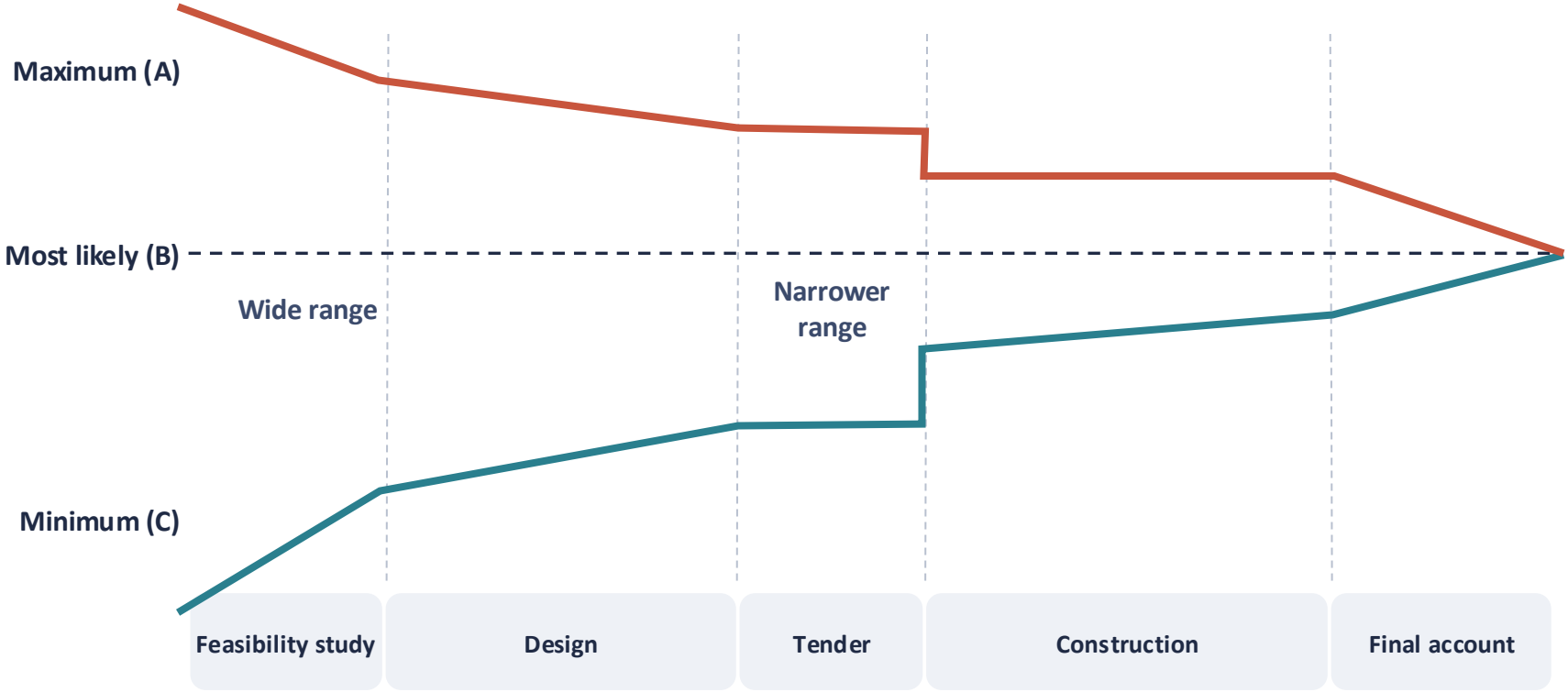
Estimates through the project



Project cost rises over time →

From Smith, N, 2008

Accuracy through the project



The range narrows as the project is defined; 'most likely' sits nearer the maximum.

From Smith, N, 2008

Why we under-estimate

The ‘minimum’ sits further from ‘most likely’ than the ‘maximum’: it is natural to underestimate project cost (and time).

Cost growth

Projects often experience cost growth or escalation.

Uncertainty

We cannot foresee all outcomes: a project is uncertain.

Bias and heuristics

Natural psychological traits affect project decision making and analysis, leading to under-estimates.


JFMPC
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Rethinking construction cost overruns: cognition, learning and estimation

Ahiaga-Dagbui D. Dominic and Simon D. Smith

Abstract

Further reading: Ahiaga-Dagbui and Smith (2014), Rethinking construction cost overruns: cognition, learning and estimation
(see: “Suggested Articles for Further Reading” on Learn)

Errors of bias and heuristics

From 'Project Decisions: The Art and Science"' (Virine and Trumper)

Insufficient Adjustment – The tendency of decision-makers to "anchor" on a current value and make insufficient adjustments for future effects. In project management this bias often manifests itself in the estimation of uncertainties. A project manager often does not allow sufficient adjustment after making three-point estimates of an activity's duration or cost.

Optimism Bias – The tendency to be overly optimistic about the outcome of planned actions. This bias manifests itself in project planning and forecasting. Project managers often overestimate the probability of successful project completion and underestimate the probability of negative events. The optimism bias is also related to wishful thinking

Overconfidence in Estimation of Probabilities – A tendency to provide overly optimistic estimates of uncertain events. Decision-makers tend to set the ranges of probability too low and remain overconfident that these ranges will include true values. Overconfidence is most likely after a series of project successes, and it can lead to risk-taking.

ON LEARN


APPENDIX B

Heuristics and Biases in Project Management

Appendix B: Heuristics and Biases in Project Management

The book itself is unfortunately not available in the library.

Also:


Documents

Optimism bias

Details

HM Treasury: Optimism bias guidance

03

Financial resources

Expenditure, income, liability and earning – and why timing matters

Financial resources

Estimating determines the cost of physical resources. First, we need to appreciate how financial resources are managed.

Liability

Incurred by the receiver of work or service

after the agreed period

Expenditure

Money flowing out when payment is made

Earning

Created by the provider once work is carried out

after the agreed period

Income

Money flowing in when payment is received

Financial resources: expenditure

EXPENDITURE

The flow of money out of the company as the contractor delivers and invoices are paid.

For example, expenditure could occur to:

- Suppliers of materials
- Subcontractors for work carried out
- Internal or external plant hire companies
- Directly employed labour
- Overheads

The client also incurs expenditure in paying the contractor.

Financial resources: income

As money flows out of a company (client or contractor), money also flows in as payment for work undertaken. To survive and grow, income must be greater than expenditure.

SURPLUS

Income – Expenditure

A measure of financial performance

A negative surplus means expenditure is greater than income. Either:



The estimate was wrong



Actual costs are not being controlled adequately

Financial resources: liability

1

Work or service provided

This rarely happens at the same time as an exchange of money.

2

Liability incurred

The receiver of the work or service owes the provider.

3

Agreed period passes

Payment is made after the agreed period of time.

4

Becomes expenditure

The liability turns into expenditure.

In a similar manner, the provider of the work or service has generated an earning.

Financial resources: earning

Work done

The company has created something of value.

Earning

That value is the earning.

Income

After the agreed period, the earning becomes income.

Why it matters

The period between doing work and being paid varies considerably, so profitability during construction is often better judged by comparing liability and earning. The difference is well illustrated by curves.

A contractor's spend pattern

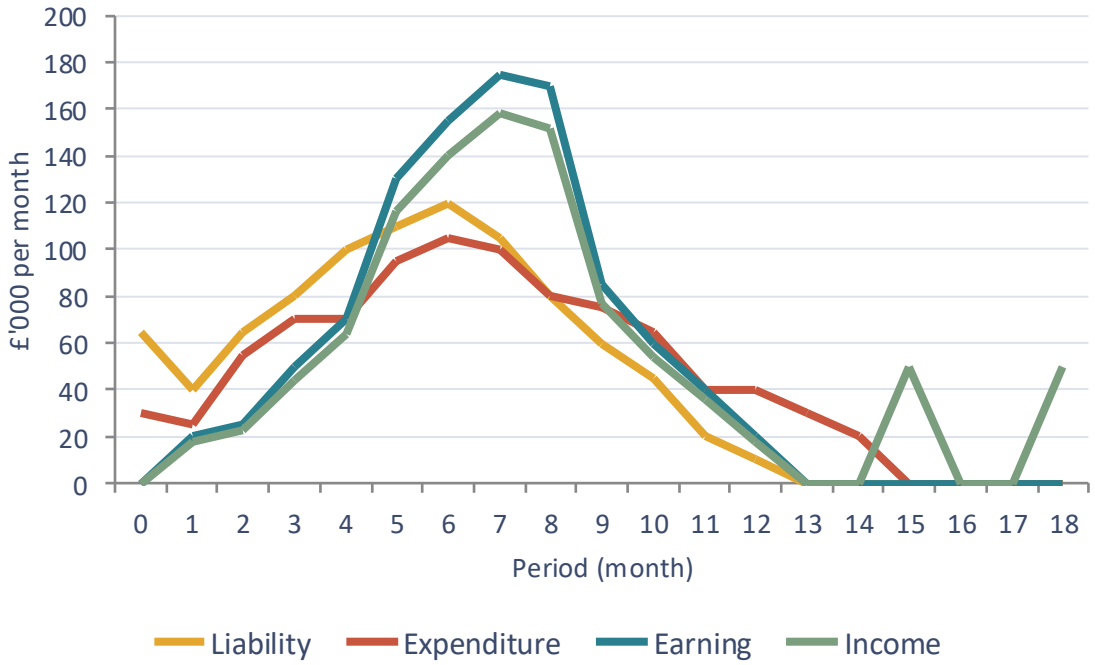
Period (Month)	Period Liability	Period expenditure	Period Earning	Period income
0	65	30	0	0
1	40	25	20	18
2	65	55	25	23
3	80	70	50	44
4	100	70	70	64
5	110	95	130	116
6	120	105	155	140
7	105	100	175	158
8	80	80	170	152
9	60	75	85	77
10	45	65	60	54
11	20	40	40	36
12	10	40	20	18
13		30		0
14		20		0
15				50
16				0
17				0
18				50

THE EXAMPLE

Monthly liability, expenditure, earning and income for a contractor over 18 months.

Next: accumulate each series to see the curves.

A contractor's spend pattern

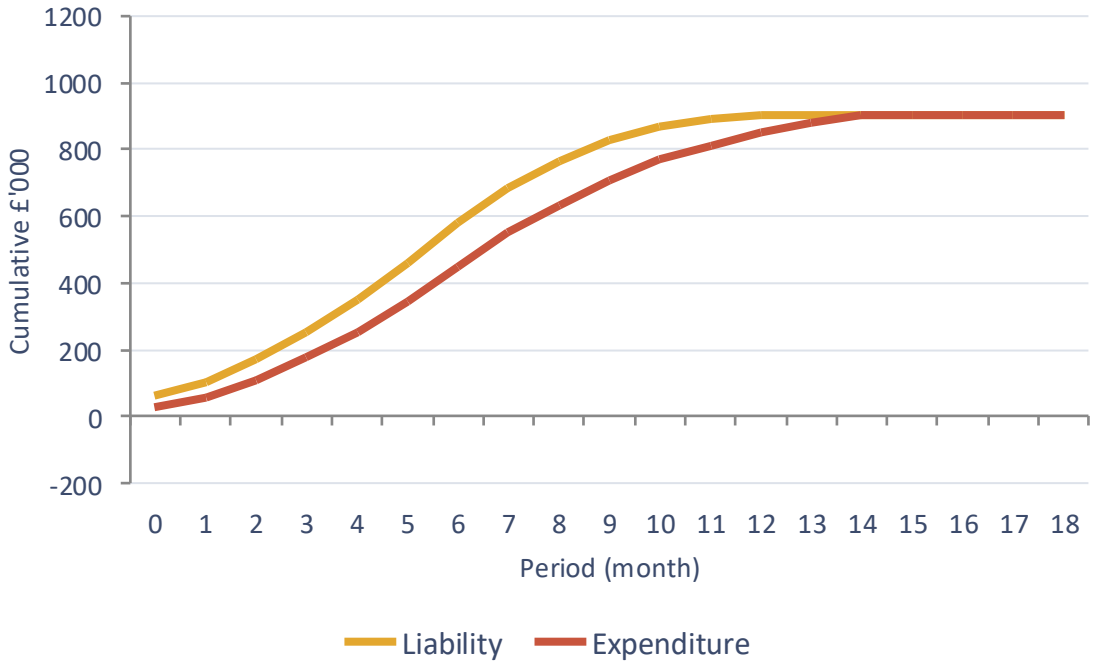


THE EXAMPLE

Monthly liability, expenditure, earning and income for a contractor over 18 months.

Next: accumulate each series to see the curves.

Curves: liability leads expenditure



Time difference

Work is received before it is paid for, so liability builds ahead of expenditure. Both reach £900k.

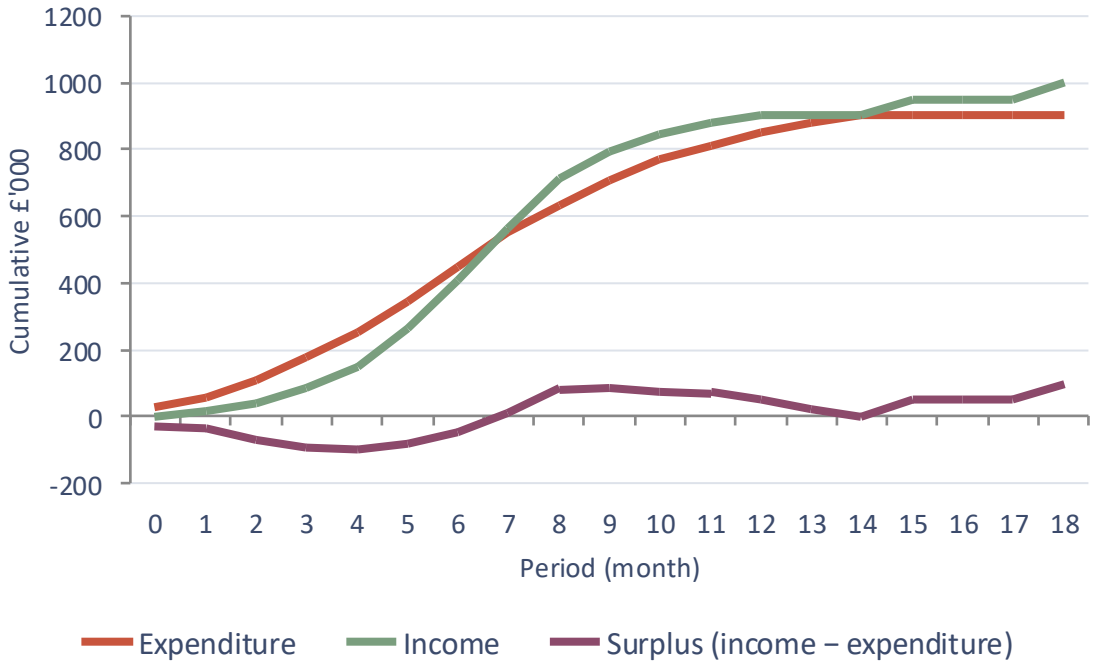
Curves: income lags earning



Cashflow lag

Value is earned before money arrives. Both reach £1,000k, income only once the retention is paid (months 15 and 18).

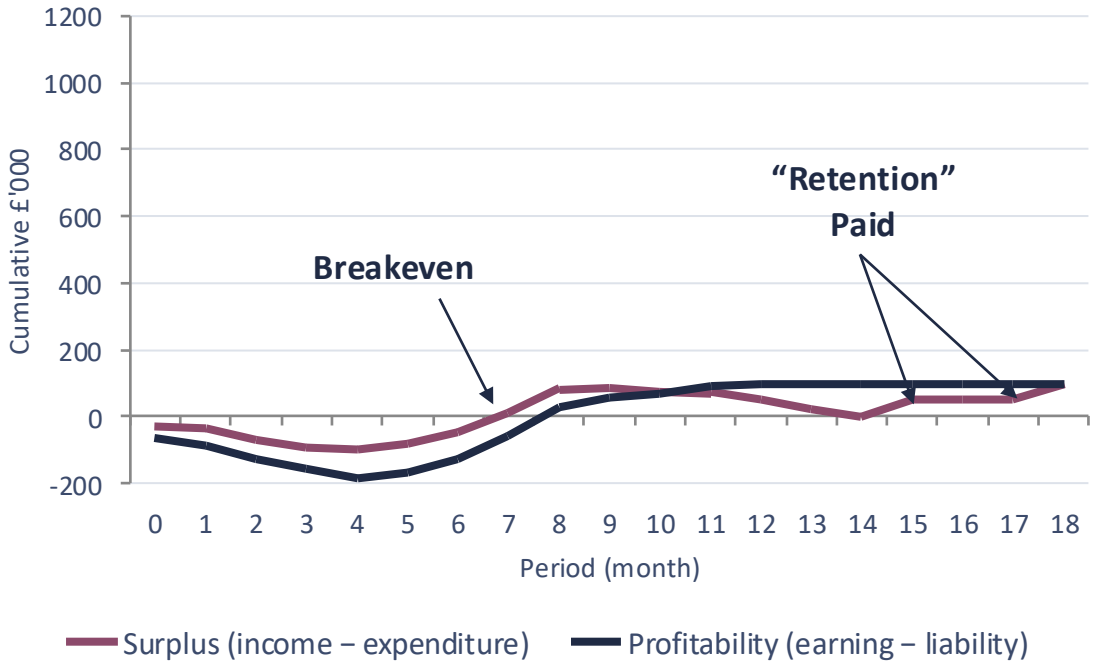
Curves: surplus



Breakeven

Income overtakes expenditure between months 6 and 7. The surplus bottoms out at about −£101k in month 4 and ends at £100k.

Curves: profitability



Profitability

Earning less liability dips deeper (about –£185k, month 4) and turns positive later (month 8). Both end at £100k.

Retention

5%

typically held back from each interim payment

1. Money held back by the promoter
2. Creates a fund to cover the cost of any eventual defects
3. The client is effectively a trustee of a trust fund
4. Eventually paid to the contractor after a pre-agreed period or at the end of the contract
5. How it is used varies widely by industry and type of contract

04

Building the estimate

Elements of cost, cost data, applying the data and the methods to come

Elements of cost

Break the overall project cost into similar, identifiable areas. The main areas are:



Personnel



Equipment



Materials



Sub-contractors



Specialist services



Overheads



Risk

Total project cost

Cost data

Once the cost ‘headings’ are established, cost data needs to be gathered.

A cost element can be expressed as:

- **Period based** e.g. £/hr
- **Fixed** e.g. £/item
- **Unit output** e.g. £/m³

How costs are determined depends on the type:

- Personnel
- Equipment
- Materials
- Subcontractors
- Overheads & finance costs

Applying the data

Cost areas identified

Cost rates identified

NEXT

Bring them together to determine the whole project cost

There are various ways to do this, depending on:

- The purpose of the estimate
- The stage of the project

Early estimates are broad

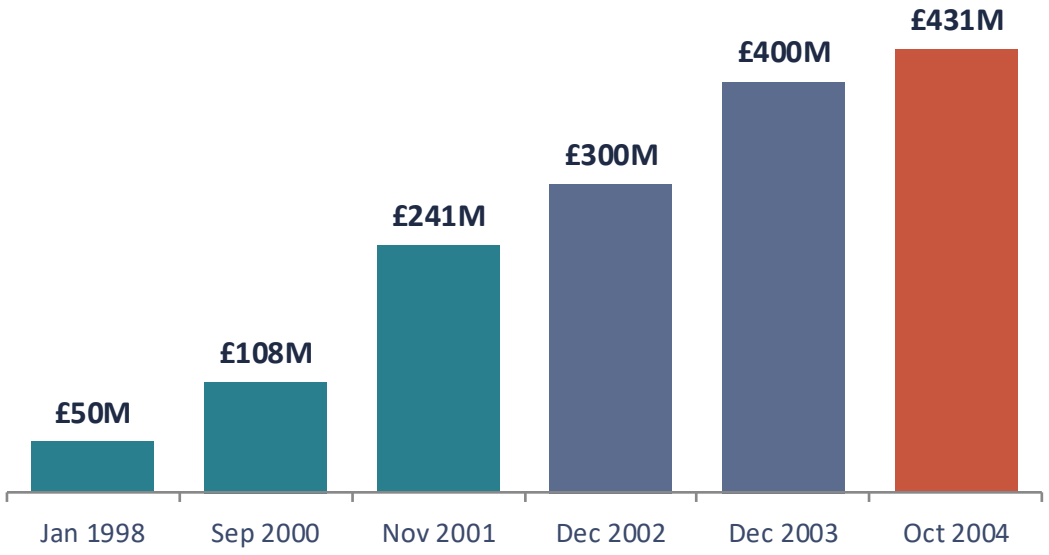
At early project stages the estimate's accuracy will be low…

1. An exact figure is not required
2. The scope of the project is not known
3. Design details are not known
4. 'Broad' techniques must be used



Consider the example of the Holyrood Parliament

Case study: Holyrood Parliament



Dec 2002 and Dec 2003 figures were approximate. Building first used 7 September 2004.

£50M to £431M

Jan 1998, when the scope was not known, to Oct 2004

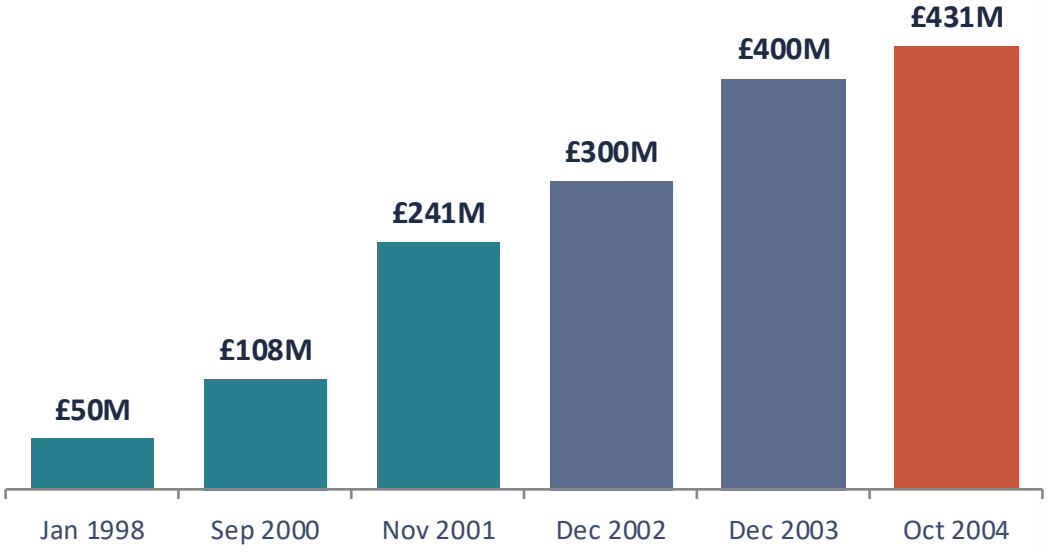


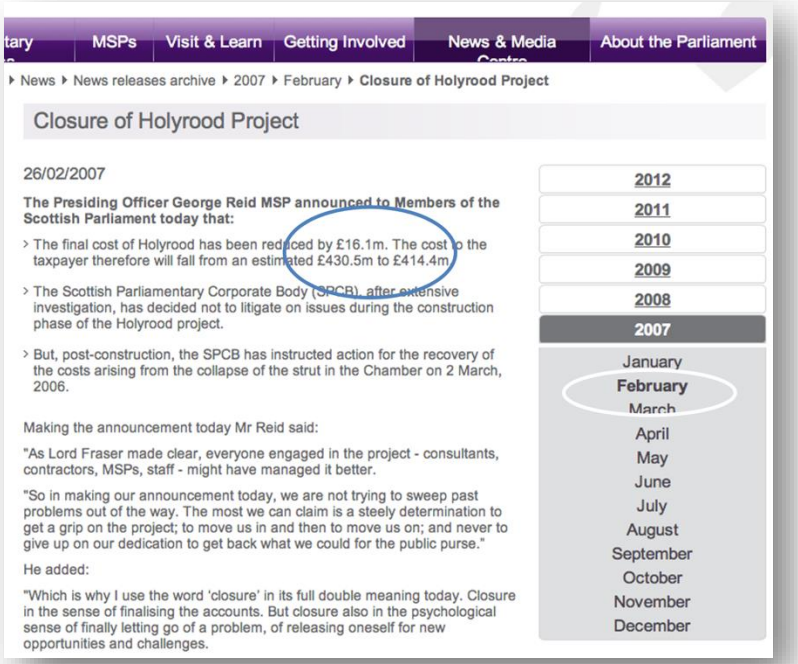






Case study: Holyrood Parliament




tary MSPs Visit & Learn Getting Involved News & Media About the Parliament

News ▸ News releases archive ▸ 2007 ▸ February ▸ **Closure of Holyrood Project**

Closure of Holyrood Project

26/02/2007

The Presiding Officer George Reid MSP announced to Members of the Scottish Parliament today that:

- The final cost of Holyrood has been reduced by £16.1m. The cost to the taxpayer therefore will fall from an estimated £430.5m to £414.4m
- The Scottish Parliamentary Corporate Body (SPCB), after extensive investigation, has decided not to litigate on issues during the construction phase of the Holyrood project.
- But, post-construction, the SPCB has instructed action for the recovery of the costs arising from the collapse of the strut in the Chamber on 2 March, 2006.

Making the announcement today Mr Reid said:

"As Lord Fraser made clear, everyone engaged in the project - consultants, contractors, MSPs, staff - might have managed it better.

"So in making our announcement today, we are not trying to sweep past problems out of the way. The most we can claim is a steely determination to get a grip on the project; to move us in and then to move us on; and never to give up on our dedication to get back what we could for the public purse."

He added:

"Which is why I use the word 'closure' in its full double meaning today. Closure in the sense of finalising the accounts. But closure also in the psychological sense of finally letting go of a problem, of releasing oneself for new opportunities and challenges.

2012
2011
2010
2009
2008
2007
January
February
March
April
May
June
July
August
September
October
November
December

Dec 2002 and Dec 2003 figures were approximate. Building first used 7 September 2004.

Estimating methods

BROAD

DETAILED

1	2	3	4	5
Global / approximate	**Factorial**	**Labour-hours**	**Unit rate**	**Operational**

The first three could be described as ‘broad’.

The last two are much more detailed and ideal for tender estimating.

Data required: Project Data

Global / approximate	Factorial	Labour-hours	Unit rate	Operational
• Size / capacity • Location • Completion date	• List of main items • Location • Completion date	• Quantities • Location • Key dates • Simple method statement • Completion date	• Bill of quantities • Location • Completion date	• Materials quantities • Method statements • Programme • Key dates • Completion date

From Smith, N, 2008

Data required: Cost Data

Global / approximate	Factorial	Labour-hours	Unit rate	Operational
• Overall costs of similar projects • Inflation indices • Inflation forecasts	• Factorial estimating system • Quotes for main plant items • Inflation forecasts	• Hourly rates • Productivities • Overheads • Materials costs • Hourly rate forecasts • Material costs forecasts • Plant data	• Historical unit rates for similar work items • Preliminaries • Inflation indices • Inflation forecasts	• Labour rates and productivities • Plant costs and productivities • Materials costs • Overhead costs • Materials costs forecasts • Plant capital and operating cost forecasts

From Smith, N, 2008

Key takeaways

Estimates are forecasts

Clients want certainty, but a project cannot be estimated before it is planned.

Accuracy comes with definition

The range narrows through the project, yet bias pushes us to under-estimate.

Timing of money matters

Liability and earning come before expenditure and income: see the lag and breakeven.

Early estimates are broad

When scope is unknown, as at Holyrood, accuracy is low.

Next week

Estimating concluded

Includes methods

Case study

