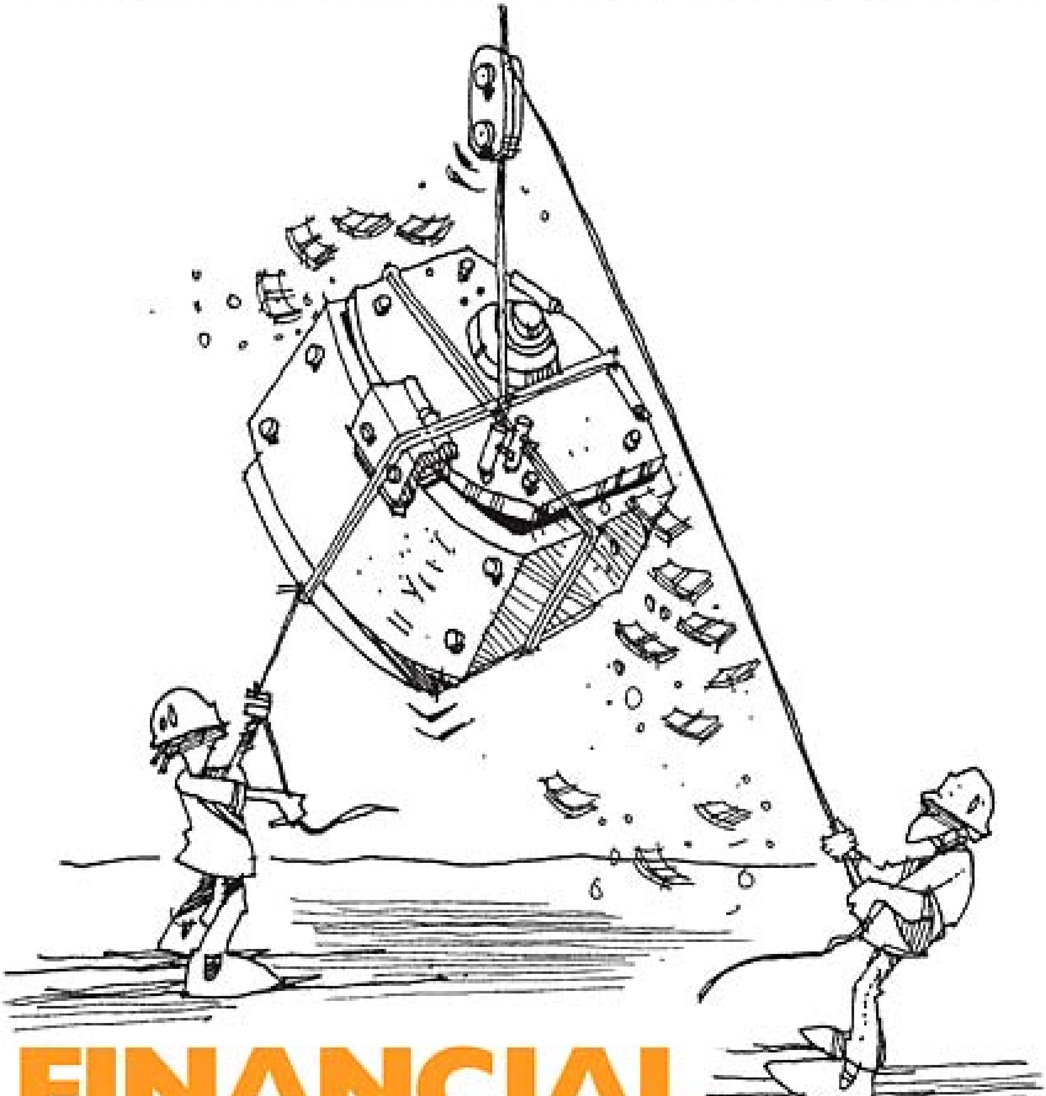
GEORGE SOLT AND RICHARD HILL



FINANCIAL FUNDAMENTALS FOR ENGINEERS

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FINANCIAL FUNDAMENTALS FOR ENGINEERS

This book explains what

ENGINEERS

should be taught about

MONEY

(but usually have to learn the hard way)

Richard Hill and George Solt

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CONTENTS

INTRODUCTION

There is a traditional gap in engineers' education, which is an understanding that **engineering projects depend as much on financial matters as they do on technology**. Without money projects don't get built, and without profits there would be no incentive to build them. In 1996 George pioneered a course on this for final-year civil engineering students at University College London, and Richard took over the course in 2002. We now teach it to BEng, MEng and MSc students in civil, mechanical, chemical and biochemical engineering. When mature engineers hear about it, they all say "Gosh! I wish they'd taught me that when I was a student. I had to learn the hard way". This book is based on that course and **aims to fill the gap in engineering education for both students and young engineers in industry**.

We both graduated in chemical engineering – George in 1950 from Battersea (now the University of Surrey) and Richard in 1970 from the University of Leeds. George spent thirty years in industry in Technical and R&D roles before becoming a full-time academic; while Richard worked for twenty years in Design and Proposals, followed by fifteen years as an independent consultant. We two have worked together for so long, first in process plant contracting and then as teachers, that we can speak with one voice. We were both in the specialist field of water treatment plant contracting, but the experiences we had and the lessons we learned are applicable to all areas of project engineering. **When you read "I" it might be either one of us speaking, but it really makes no difference**.

We've written about contracting because that was our field, but **this stuff is vital for all engineers – and indeed everyone who deals with projects**, something which is liable to happen sooner or later to most engineers, either as Contractor or as client. There's nothing difficult in the detailed information in this subject, so why does it have to be learnt? It's because **in this field everything is interconnected – that's why the book is full of cross-references, both forwards and backwards** (they're indicated by an arrow and chapter number). The difficult thing about this subject is to understand how the whole system works.

Chapter 23

We have over-simplified things whenever we could do so without actually misleading anyone and, to keep things simple, most of our definitions are over-simplifications as well. **You'll find that some points are repeated and some bits are duplicated**. We make no apology for this. Some things are so important that it's worth saying them over again. On the other hand, we've included less important but interesting or, perhaps, even entertaining bits, in boxes so they're easily skipped. Most of these are anecdotes which relate our own experiences, and we hope that they'll help to explain why it's so important for engineers to have a good understanding of financial matters.

> The Literary Correspondent of The Times once published an article about the Oxymoron – that is, a figure of speech which combines opposites (the Oxford Dictionary uses "languid energy" as an example, and I recall a publication for reinforced concrete designers called "Concrete Abstracts"). In reply, a chap wrote a letter to the Times claiming that he now understood an ad in his local paper, where they were recruiting a secretary for "an expanding contracting company."
>
> This has no relevance to anything in this book except that it deals with the contracting industry.

Finally, we would like to record our thanks to Peter Varey, who did a lot of painstaking editing for us, entirely out of the kindness of his heart, and provided invaluable advice and encouragement.

Richard Hill
George Solt

1

WHAT'S IT ALL ABOUT?

It's all about money

Engineers create wealth. It really is as simple as that. There's an old American saying that an engineer is someone who can do for half a dollar what any fool can do for a dollar. That's because engineering means making the best use of real resources – materials, power and labour, and they're all measured in terms of money.

We create wealth by finding cost effective solutions to problems. Railways, aeroplanes, atomic bombs, agricultural machines, electricity generation, mass production of chemicals and pharmaceuticals, computers, water supply, etc. Engineers have made their mark in every area of human endeavour, and they have done it by reducing costs.

Back in the 1960s, Alec Issigonis designed the iconic Mini, which was a masterpiece of engineering innovation. It carried four people in the minimum of space, used petrol thriftily, and was affordable. Compare the Mini with the Rolls Royce of that era, which carried the same number of people but in a large and very expensive gas guzzler. It's not hard to design a car, given the freedom to use the most expensive materials, take as much space as you like, and put in it a large and uneconomical engine – in short spend unlimited amounts of money. The Mini did the same job for a fraction of the cost.

My colleague the keen Sales Director had a Rolls Royce Phantom III (1937 model) of which he was immensely proud. It weighed $2\frac{1}{4}$ tons and did 7 miles to the gallon. People often asked whether they might look under the bonnet. There they would find a downsized version of the "Merlin" engine – the one which powered the Spitfire and other famous World War II aircraft: a 7-litre V12 engine, with 24 sparking plugs and twin magneto ignition. "What a beautiful piece of engineering!" they would exclaim. But of course it was the exact reverse – it was a classical case of bad engineering. Ettore Bugatti (1882–1947), who knew a thing or two about motor car design, said of Rolls Royce that they "represent the triumph of mechanics over engineers".

Chapter 7

Chapter 25

Who benefits?

Ultimately it's Society or 'the public'. Unless there is a benefit to the general public, engineering innovations fail. Naturally, individuals and corporations make money on the way: engineers are no more altruistic than their fellow humans. But that is what provides the impetus for innovation. When Isambard Kingdom Brunel built the Great Western Railway he did it for the benefit of the burghers of Bristol, who wanted to compete with London docks for transatlantic trade, and paid him well for his efforts. But the benefit of lower cost travel between London and the west is still with us.

There are many textbooks on 'management'. Most, in my experience, are poor. I do, however, commend *Up The Organisation* by Robert Townsend (published by Michael Joseph 1970). His answer to the question at the top of this chapter is "If you can't do it excellently don't do it at all. Because if it's not excellent it won't be profitable or fun, and if you're not in business for fun or profit, what the hell are you doing here?"

So, ultimately, businesses exist to make money – that is a profit – for someone.

Where's the technology?

We create wealth by innovations in technology or its application but good engineers are not, primarily, technologists. We create wealth by using our ingenuity to solve problems. Unfortunately it's not easy to teach this sort of thing, so the teaching of engineering concentrates on teaching only its technology, which is easy to teach and easy to assess in exams.

It's a bit like music: you can teach a student musical composition but that doesn't necessarily mean that he will be able to compose beautiful music.

But engineering projects live or die by money not technology, and most university courses don't tell you about that. That is why we pioneered this course at University College London, and have written this book which covers much the same ground.

What's a project?

I've used the word 'project'. The best definition I've come across for a project is "something that's never been done before", though we are here concerned only with engineering projects. Whether it's a tunnel under the Channel, a space station in orbit, a bacteria-driven computer chip, an oil refinery or a footbridge over the Thames, every new engineering project is different. It needs to be designed and it needs to be built. And it needs to be built economically.

The word 'engineer' comes from the same Latin word as 'ingenious'. That takes on board the fact that we have to use creative skills and inventiveness to solve problems.

'Projected' (something that's going to be done in the future), and 'Projectile' (something that's chucked a long way) are also derived from a common root. Remembering these two helps to remind us what projects are about.

The fact that a project is something new means that there must be more or less uncertainty about its outcome. Can we really build it for the budget and in the time? Will it be profitable? Can we afford it? Can we do it at all? There are unknown ground conditions that can affect not only the foundations but the whole approach to construction. Marc Brunel, Isambard's father, invented a tunnelling shield to construct the Rotherhithe tunnel. It was innovative, completely untried and had to be developed on the job.

It seems that when they started to build the famous Sydney Opera House it couldn't actually have been built to the original design (Civil Engineers on the whole are pretty cynical about Architects for occasionally landing them with this sort of situation). It was only saved from oblivion by a radical re-design.

How do we build it?

Most people who want something built don't have the necessary skills or resources. Building something like an oil refinery requires a multidisciplinary team of engineers – chemical, mechanical, structural, electrical and civil – to create the design, and then a vast team of skilled builders, scaffolders, pipe-fitters, riggers, electricians, crane drivers, and so on. These people need to be organised so that their efforts are coordinated. The construction industry provides those skills. The industry covers every scale of construction from the local builder who constructs house extensions to the international corporations that build power stations, chemical factories and airports. Construction companies build projects for their clients in return for money. The arrangement between the client and builder is called a contract and the builder is called a contractor.

The Contracting Industry

As we'll see later, contracting is very competitive in any particular sector. Only a few large contracts are placed every year and it is important for a contracting company to win enough of them to survive. This means that profit margins on turnover are low – typically 1.5 to 5% – although, as we'll see, the return on capital invested is quite good.

Chapter 3

Two people are key to the success of a contract: the Project Manager, who is the Client's representative (he often used to be called 'The Engineer') and the contract manager, who is the contractor's representative, and manages the contract. The success or failure of a project often rests on the relationship between them. This book is very largely about how this relationship works.

> I worked for a specialist process plant contracting company and we had sold a water purification system to a large pharmaceutical company. The contract was successful although there were several disputes during its execution. The following year I was approached by the pharmaceutical company's Project Manager to see if we would bid for another water purification system at another factory because they were very pleased with the plant we had built. However, he told me that if we were to be given the opportunity to bid we'd have to nominate another contract manager!

In fact, many of my ex-students have gone on to become highly successful Project Managers, contract managers and, indeed, Managing Directors, but, one way or another, they had first to understand about money.

Most engineers will sooner or later have some dealings with the contracting industry, either as an employee of a contracting company or as a customer of one, so it's important to understand how contracting operates as a business. In its basic respects its structure and management is much like any other business, but it has several unique characteristics, particularly in the area of finance. Before we get to them we have to consider what money itself is about.

Summary

- **Engineering is about money**
- **Project Engineering is about risks**
- **You have to understand about money.**

2

MONEY

What is it?

I define Money as the stuff we haven't got enough of. That's a good oversimplification for a start and economists probably hate it, but it makes an important point: The Engineer's job is to meet some demand by the most efficient use of scarce resources – labour, power, materials. Our common measure for all these is money – it's a terrible measure, but the only one we have.

A Brief History of Money

This will help to understand where we are now.

For thousands of years, people traded by barter – wheat for oil, peacocks for sandalwood, and so on. In time they found that ingots of metal had three properties which made them particularly useful for trading, and so they became the basis for money. Compared with other useful goods, metal was:

- a valuable and scarce resource,
- compact and easily transported, and
- not perishable.

At first, bits of metal were used for trading, their value set by their weight. It became what we now call money when they stamped bits of standard sizes with some mark to indicate a value – but that value was their weight of gold, silver or copper.

> The Chinese 'Tael' was a silver ingot with a standard weight of 37.4 g, whose value depended on the price of silver at the time. Snipping metal off coins and melting it down was rife in the middle ages, until someone had the bright idea of giving coins milled edges.

Carting about quantities of precious metal, in whatever form, may be less troublesome than the corresponding value in the form of wheat or peacocks, but it is still cumbersome and dangerous. To overcome these two problems, banks in the middle ages gave merchants credit notes which could be cashed in at the bank. That improved compactness and portability, as well as security.

In 1941 the Abyssinian currency was the Maria Theresa dollar, an Austrian silver coin which had been withdrawn from circulation there long before. Its value was the weight of silver, and Turkish and Egyptian silver dollars (of which there were a few) were just as acceptable. In World War II the invading British army needed great mule trains, saddle bags filled with silver, to pay their local auxiliaries.

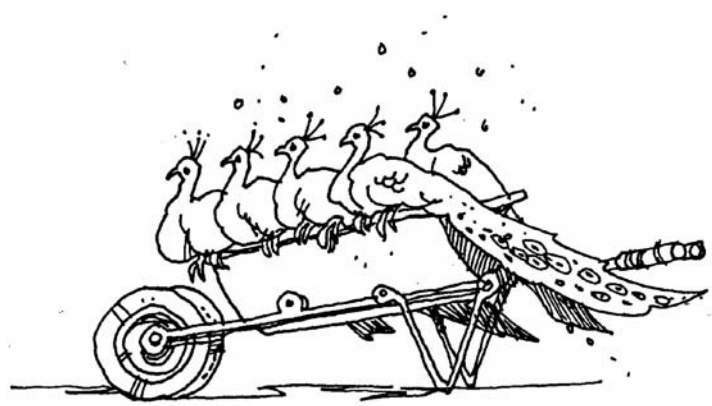


Figure 1 *Paying with Peacocks*

Starting in the seventeenth-century 'bank notes' which could be cashed by anyone, were issued by Dutch banks, who claimed that they had enough gold and silver in their vaults to cover the total value of all the notes they issued. (Our bank notes still say "I promise to pay the bearer on demand the sum of ….".) Quite soon that stopped being true but (as long as there wasn't a run on the bank, when they wouldn't have been able to cover the value of all the notes which they had issued) they still represented gold and silver, a valuable and scarce resource.

The system collapsed after World War I. First the Austrian and German currencies became worthless, and then around 1930 both Britain and America stopped pretending that their paper money was convertible into gold. The link between money and a scarce resource had been broken.

There was now no obvious limit to how much money could be printed. Some people, however, were surprised to find that the more money was printed, the less it was worth. Inflation had arrived.

Until 1931 the UK currency included a little £1 gold coin called the 'Sovereign', which weighed 7.32 g. It is no longer a coin of the realm, but is still being minted today for ornaments, or those who like to hoard their money in the form of gold. In 2005 it cost about £50 to buy. If we assume that the value of gold is constant (it isn't, but it doesn't vary enormously), this represents an inflation rate of $5\frac{1}{2}$ % p.a. over 74 years.

From 1940 silver coins were progressively replaced by cupro-nickel – more durable, they said, but also relatively worthless. By 1950 there were very few still left in circulation. By 1971, when the old Pounds, Shillings and Pence (£.s.d) were changed to metric currency, the copper content of the old penny coin actually cost more than its purchasing power, so the Royal Mint was producing them at a loss.

Inflation

Engineering depends on accurate measurements, for which we have units like grams and kilowatts. Money, our only way of measuring the value of scarce resources, is not only notoriously inaccurate, but it is highly variable. For example, if you were to read in a textbook that a ton of sulphuric acid costs £25 it wouldn't mean a thing. You would first have to find out when that was written, and how much inflation there has been since then.

Inflation is good news for borrowers, because the real value of their debt goes down, so Governments, who are the biggest borrowers of all, should love inflation. Their trouble is that the voters don't, especially those with fixed incomes, like pensioners. As one might expect, Governments are therefore likely to aim at the highest rate of inflation which won't bother too many voters – at the time of writing (2005) UK Government has set a target of 2% p.a. and the actual rate has even been a bit lower. As a result, for the first time ever, there have actually been complaints that inflation is too low!

Most likely, therefore, inflation will always be with us, unless the world gets on to a more sensible means of measuring the value of scarce resources. At some future time the system may well go out of control again and inflation will get high, just as it did in the 1980s, when we had inflation at 16% p.a. Pricing and financing projects was really difficult then. We had to guesstimate how much our costs would have risen by the time the job was finished. As an alternative to offering contracts at a fixed price, there were complicated formulae based on officially-issued statistics, which adjusted the selling price of a project to take inflation into account. Either way, it was a nightmare.

Even then, 16% inflation is chickenfeed compared with Germany and Austria in the 1920s, when a postage stamp could cost millions or even billions of Marks or Schillings. Many countries, like for instance Brazil, have had inflation on that kind of scale more recently.

Measuring the rate of inflation needs some measure of 'constant' value. Gold and Silver used to serve in the past, but what are we to use now?

> The Government makes up a 'basket' of commodities and finds out regularly how much that would cost, to establish how inflation is going. This basket is some kind of a constant unit, and it works quite well, but it doesn't provide us with a unit to use in everyday calculations – even if it's full of Mars bars.

Some years ago an ingenious journalist claimed that the Mars Bar hadn't changed in decades (he was wrong there, actually!) and could be used as a measure of constant value. It let him work some striking examples in terms of Mars Bar Economics to show how borrowers profit from inflation – which naturally means that lenders lose from it. I myself think the kWh is a better measure of constant value – it seems more plausible, but the name 'Mars Bar Economics' has a certain swing to it.

Below is an example to show what happened when inflation rates were higher than interest rates. The figures are approximations, but accurate enough to give a true picture of the effect.

How Mars Bar Economics made some of us rich

When inflation was up to 16% p.a., one could still borrow money at much lower rates – an incentive to borrow as much as possible.

Suppose in 1975 I bought a house for £80,000, paying £20,000 in cash and the rest by borrowing £60,000 to be repaid after 15 years, at 6% p.a. interest – i.e. £3600 p.a., which would come to a total of £54,000 in 15 years.

Suppose inflation between 1975 and 1990 averaged 10% p.a. In 1975 a kWh cost 1.5p. Assuming that it has a constant true value, its cost in 1990 would then be about 6p, and the average cost of a kWh during those 15 years 3.75p.

£80,000 in 1975 was equivalent to 5333 MWh, and we'll assume that this was the true value of the house, and that it remained constant.

In 1990 I sold the house for its true value, which at 6p/kWh brought me £320,000, so the whole deal works out like this:

MONEY GOING OUT

	£	Mwh
Cash (1975)	20,000	1333 @ 1.5p/kWh
Interest (1975–1990)	54,000	1440 @ 3.75p/kWh
Repayment (1990)	60,000	1000 @ 6.0p/kWh
TOTAL COST	134,000	3773

MONEY COMING IN

Sold (1990) for	320,000	5333 @ 6.0p/kWh

So I lived rent free for 15 years and made a cash profit of 1560 MWh (= £94,000 in 1990) – which is almost a third of the real value of the house.

Now you will understand why many old age pensioners are quite well off today. The next generation won't be so lucky.

Interest

To hire a house or a car means paying rent. Money is actually more useful than either a house or car, because it can buy either, or both, so naturally hiring money also means paying rent for it – it's called 'Interest'.

Why has interest always had such a bad press? Charging extortionate rates of interest is of course wrong, but charging extortionate rent for a house is just as bad, and the Bible doesn't mention that.

The Bible has some hard words about lending for interest, and the Koran actually forbids it, but the banks tend to ignore the Good Books when it suits them.

A lender is reasonably entitled to get some return for lending money, but what is a 'reasonable' rate of interest? Historically, it is roughly between 1.5 and 3% p.a. for an absolutely cast-iron safe loan. Absolutely cast-iron safe loans hardly exist, so in real cases we have to think how other influences affect it.

Suppose I lend £60 for 10 years to each of 100 people: what interest should I reasonably charge?

The first problem comes from inflation. Suppose a kWh now costs 6p, so that my £60 is now worth 1 MWh. After 10 years at 2% p.a. inflation, the £60 repayments which I expect to receive will only buy 0.8 MWh each, so I must charge 2% p.a. interest just to offset that loss.

Then there is the risk that some of my debtors will die, go bankrupt, or just disappear. If I reckon that each year I may lose 2 out of the 100 debtors, I must stick another 2% p.a. on the interest to break even.

I'll have to chase up the debtors to make sure of getting the annual interest payments and to get the loans repaid at the end – the cost of the necessary administration for that might come to, say, another 1%.

So far we have:	Inflation	2% p.a.
	Risk	2% p.a.
	Administration	1% p.a.

On that basis, 5% p.a. interest would only just break even. If I am content with a modest return of a real 2.5% p.a., the interest rate which I have to charge comes to 7.5% p.a. It sounds a lot, but (on the above assumptions) it's 'reasonable'. As you will probably know all too well, Credit Card interest rates are at least 10% p.a. and often much more. This reflects that they have high admin costs and expect quite a lot of defaulters, but only in part. At the time of writing, there is a report on store card interest rates, which are far higher.

Borrowing rates may or may not be quoted as 'APR'. With high interest rates, the difference between simple and compound interest becomes significant, even over short periods. Credit cards charge interest monthly, and 'APR' is the annual rate taking that into account.

For example, a rate of 17% simple interest means £17 annual interest on a £100 debt. With credit cards charging interest each month, the interest of 1.417% per month means the annual interest to be paid on that £100 debt is £18.39p.

So the variables which combine to make up actual interest rates are: Inflation, Risk, Administration, and Real Return. It's only the real return which should be 'reasonable' – the others are a matter of fact.

The Banks

As we shall see shortly, loans are a major factor in any engineering venture. The various bodies which lend money go under several names, but I shall call them all 'banks'. Essentially, they live by borrowing money at one interest rate, and lending it at a higher one. The Bank of England is the UK government's bank: its 'Base Rate' is (more or less) the interest rate at which other banks can borrow money. It is a major tool in controlling the economy. The Bank reviews the Base Rate every month. If inflation seems to be rising too high, they increase the interest rate to offset the effect. If the economy is getting sluggish, they lower it, which makes it cheaper to borrow money and so gives everyone a greater incentive to invest.

The banks are particularly important for our trade, because project engineering depends on finance being available when needed. In underdeveloped countries one often sees buildings which are half-finished and there is no-one working on them. The common cause is that work has had to stop until the necessary cash can be found to go on and

Why did the great mediaeval cathedrals take decades and sometimes centuries to build? Maybe the bishopric might have engaged more stonemasons to speed up the work, but often it couldn't. If the work was paid out of the income which the bishopric could raise every year, it probably couldn't raise the money any faster and that limited the speed at which the work could go on.

finish the job. With good finance services, once the necessary loans for a project are agreed, the banks can produce money the instant that it is needed. You will notice here and there that I am not very fond of our banks, but we must never forget that the banks provide a number of essential services, of which this is just one.

Banks do not set 'sensible interest rates' using the logic I've just set out: they decide in each individual case how much to charge. To put it less politely, they charge the highest interest rate they think they can get away with. In practice, it is only competition which keeps the banks' actual rates near the 'sensible' level. For some reason store cards don't seem to suffer so much from competition, and they take full advantage of that.

This means that a less-than-totally safe client has to be charged higher interest – but how much higher? Is the risk too high to make a loan at all? In making these difficult decisions the banks are torn between cowardice and avarice.

> A banker friend once told me that American banks tend to give in to avarice, and the British to cowardice. He claimed to have got some system going by which he could make money out of this cultural difference.

So in individual cases, the 'risk' factor decides the actual rate and, more importantly, whether a bank is prepared to lend money at all. A well-established company with good security can typically borrow money at (Base Rate + 1%) and its overdraft charge will be (Base Rate + 2%). Just a whiff of the slightest risk and not only do the interest rates go up, but the bank may impose all kinds of conditions, such as having the company's Directors put their private homes at risk.

> To put it another way – the banks refuse to lend to people who really need money, but they'll press those who don't need it to borrow more. Getting loans depends on appearing safe and solid to the bank. Some desperate games of deception are often played to achieve that. The banks also have some charmless devices which make it difficult for their clients to move their account. The aim of that is to make it difficult for borrowers to take advantage of the opportunity of a lower interest rate which they might pay to a competing bank. The Government has recently criticised them severely for this, but there's often not a lot that can be done about it.

Well, that tells us a bit about what money actually is. Being engineers you now need to know how to measure it.

Summary

- **Money is an inaccurate and variable measure**
- **Borrowing money means paying interest**

- **Interest pays for inflation, risk and admin costs before producing any real return to the lender**
- **Banks usually refuse to lend any money if they see a significant risk. If the risk is slight, they may lend some, but only at high interest rates.**

3

MEASURING MONEY

Why measure it?

Because it is among the basic dimensions which you need to do anything. All engineering depends on making measurements, preferably accurate ones. Unfortunately that is where money fails miserably.

For a start, inflation makes it a variable measure. If we have to deal with exchange rates between currencies of different countries, things are even worse. But even without these obvious failings, it is elusive stuff, changing from one form to another, hiding itself only to reappear in unexpected places, and altogether difficult to pin down.

The art of measuring money in all its forms is called Accountancy. Only accountants can measure whether a trading venture is (or is not) profitable and sound, but however good and skilful the accountant may be, drawing conclusions from their results always needs care.

It really is an art. Accountants are often written off as "Bean Counters" and thought to be dull, boring people. Wrong! They trade in vague concepts and fictions. They are the last poets and dreamers left to us in this modern age.

There are two kinds of accountancy: Financial or Fiduciary Accounts, and Management Accounts.

Audited accounts

The Government obliges every company to produce an annual set of Financial Accounts, which have to be checked or 'audited' by an independent qualified accountant (a Chartered Accountant in the UK). The accounts are filed at Companies House, where they are available for public inspection. They serve two purposes: to determine how much tax the Government can extract from the company, and to show the public (investors, suppliers, potential business partners etc.) how the company is doing.

Auditors have evolved a set of rules to make the audit as reliable as possible, but it is very far from an exact science. That in turn means that the results can be 'massaged'. Naturally enough, the company's aim is to get the audit to minimise its tax bill, while presenting the best possible image to the world – two purposes which are mutually contradictory. Doing it within the law can be quite a challenge. That is why departures from the law – some great, some small – are not unknown.

See *Private Eye* magazine for occasional reports of such naughty goings-on. They blew the whistle on BCCI and Robert Maxwell for years before the law stepped in – but these are two cases where a particularly large number of citizens were cheated. Smaller examples are legion: they just don't get the publicity.

When they occur, it is hard to work out just exactly what the truth should have been – sometimes the fraud is so complex or ingenious that we never get to the bottom of it. However, as we shall see, accounts can be massaged without breaking the law. It is not always easy to know just where lawful massage stops and fraudulent accountancy starts.

Auditors have a hard time because they serve two masters. On the one hand the law demands a true and unbiased picture – if auditors do not follow the regulations, they will lose their licence. On the other hand, they get paid for their services by the company which they are auditing, so they have to please their paymaster or lose the business. It's not surprising that auditing has developed a range of practices, from slightly dodgy to completely fraudulent. Several enormous accountancy-based frauds like Enron have recently become public, but they're just the tip of the iceberg.

Anyone who thinks accounts are boring should read *The Smartest Guys in the Room – the Amazing Rise and Scandalous Fall of Enron* by Bethany McLean and Peter Elkind, published by Penguin in 2004.

Audited accounts are presented with a great show of precision but, as many of the 'measurements' which accountants make are really guesswork, the result always carries an element of doubt. There is a lot of freedom in setting up an audit, which means that even accounts which are perfectly legal may have been (and often are) massaged to give a more or less distorted picture. Here's an example of how an audit can be fudged without breaking the law:

At the end of a contractor's business year some contracts will be part-finished, and others finished but still under guarantee. All these carry some risk of costing money in the future, so provisions must be set aside to represent the foreseeable risk.

> 'Provisions' are a guess at a likely future loss. The most obvious example: when banks publish their audit, the provisions are made up mostly of loans which they think may not be repaid, multiplied by the probability of that happening. Or, a company which is in the middle of a lawsuit should make provision against the cost which would result from losing it. Whatever they are for, provisions are always going to be guesswork, and therefore liable to massaging.

This is purely a paper operation to make a guess at the probable loss of profit which can be expected. No real money is put into a savings account. How much is to be set aside this way is a matter of judgment, made individually for each contract. The auditor cannot make that judgment alone: the company will consider what it thinks is a reasonable estimate, and the auditor will accept that figure unless it is deemed to be wrong.

'Provisions' count as a loss, and reduce the year's profit. So if a company has had a good year, it will want the audit to show a high estimate for the year's provisions, for two reasons. Firstly, these 'losses' serve to reduce the profit and so reduce the company's tax bill. Secondly, by over-estimating the provisions the company creates a hidden reserve (but only on paper, I repeat) which will be carried forward into the next year. Then the surplus which is created by the unused provisions goes into the year's income and increases the profit – but at the end of the next year, there is another audit and a fresh set of provisions to be made up. If the next year has also been successful this sort of surplus can be carried forward by over-estimating a fresh set of provisions. As long as trade is good, that can go on indefinitely, with a permanent virtual reserve in the company's accounts available for a rainy day.

> I repeat that it is important to realise that this is a paper exercise which is done purely for the audit. It is not the same as hiding a pile of banknotes under the bed. No real money is put aside for the expected losses.

If, on the other hand, the year has been bad, under-estimating the provisions increase the profit reported by the audit, and that helps keep shareholders and the bank happy. As long as the individual provisions for each contract are reasonable, it's quite legal. This game is played every year, so a single year's audit must be expected to contain some such hidden sums, but in the long-term it must all come out in the wash.

Another piece of guesswork which appears in audits is 'Goodwill'. As an example: ICI's paint brand 'Dulux' has acquired a reputation for consistent high quality. Specifications for engineering work therefore often say that "painting shall be done using Dulux or equivalent quality". Years of consistent advertising (with several generations of Old English Sheepdogs appearing in Dulux advertisements) have helped create this brand image, so the reputation is partly thanks to serious investment – a type of investment just as real as investment in bricks and mortar. If ICI were to sell the paint business, the buyers would have to pay a huge sum for the brand name. This kind of asset is called 'Goodwill'. To show how valuable Goodwill can be, after Rolls Royce aero engines had split from Rolls Royce cars, the brand name Rolls Royce and its distinctive badge (as applied to cars only) were sold to BMW for several million pounds.

Any company which has built up good relations or a good reputation has acquired some Goodwill, but it does not have to appear in the audit unless there is some good reason for it. If it does, the problem is how to value it. A minimum valuation could be the cost of past publicity (Old English Sheepdogs don't come cheap) but that comes nowhere near its potential sales value in either of my two examples. The value which has been given to 'Goodwill' in an audit is always a guess. That makes legal fudging possible, but there is also room for fraud.

These are just examples of a variety of items in an audit which are largely guesswork and can therefore get fudged. In the end any fudge will come out in the wash. It therefore takes at least three consecutive years' worth of audits for a reasonably reliable look at a company's finances.

Everyone should understand what the main items in a set of published accounts mean. Lots of books teach basic accountancy but, sorry, this isn't one of them. This chapter only highlights why it is important to know something about accountancy, but you'll find a short guide to accounts in an appendix. Appendix 1

Management accounts

Management Accountancy, on the other hand, is quite separate from auditing and has a completely different objective. Management Accountancy is for telling the company's management what is going on, so cosmetic exercises are not only pointless but can be misleading.

> Our MD used to estimate the total annual cost of the Directors' bonus in advance, and add one twelfth of the sum to the monthly 'Salaries' figure in the Management Accounts. I suppose the idea was to conceal from the staff that we were paying ourselves a bonus. As this bonus, like our salaries, was quite modest, I didn't see the point. Anyway, the management accounts people must have known, so it wasn't a secret even within the company.

Whereas the audit has (by law) to be done by a licensed outsider, management accountants are company employees. The law says nothing about their qualifications, but in all but very small companies this is an important job which needs well-trained people.

Management accounts set out to measure the real state of affairs as truthfully as they can, which means it is company-confidential stuff. It tells the company's management how they're doing in general, whether individual contracts are going wrong, and what action may be needed. Speed is essential. However good the Management Accounts might be, if they turn up three months after the event, they are likely to be too late to be helpful. On the other hand management accounts don't have to be absolutely exact, just as long as they lead to generally correct conclusions.

> One of my former MDs used to move money in the management accounts from contracts that were doing well to contracts that were losing money. This had the effect of making the better managed contracts look worse than they were, and the less well managed contracts look better. It may have made the MD feel that he was running a sound company but it didn't fool anybody and, in the end, the company went bust.

When I worked in the contracting industry, we used to aim to produce monthly management accounts, one month after the event. Sadly, we didn't always succeed in doing that. We tried, but given the length of our trading cycle it was quite difficult to keep to such a short timescale. To achieve that needs cooperation from all the operating bits of the company – if the information isn't forthcoming, the accounts won't be much good. Every member of a company has a part to play there. A supermarket, which has a much shorter trading cycle, could probably produce accounts weekly, and a bookie might do the accounts at the end of the day's racing.

Generally the tools used in management accountancy are similar to those used in financial accountancy, and centre on a Balance Sheet and a P&L account. However, the object of the exercise is different, and management accounts are generally more detailed. They will include an account of any Cost Centres and show the actual cash situation.

Chapter 13

Whereas fiddling the financial accounts is illegal; fiddling the management accounts is just stupid. It is one of my qualifications for writing this book that, during my 30 years in industry, two companies failed while I was their Director. One of them went bust because the management accounts of our subsidiary were fiddled – not with criminal intent so much as through wishful thinking. They fooled the management into thinking everything was going well, when it wasn't.

Chapter 4

Figure 2 *Accountant composing a Company Audit*

SUMMARY

- **Stop thinking of accounts and accountants as boring**
- **Learn how to read what they seem to say**
- **Recognise where they might be misleading**
- **Management accounts must be prompt, informative and shouldn't mislead.**
- **The accounts department needs cooperation from everyone in the company to achieve these objectives.**

4

HOW THINGS CAN GO WRONG – 1

This is the story of a very small contracting company, newly formed to work in a branch of environmental technology which was then quite novel. A little over 50% of the shares were held by my old company, but as its location was quite distant, contact between the two was not particularly good. The MD of the parent company would visit from time to time, but there wasn't much apart from that. The rest of the shares were held by some of the staff of the company, especially their Managing Director, a well-qualified engineer whom I shall call Jim.

Jim was a charming man, all energy and optimism. In the first two or three years under his leadership the turnover increased steadily. The audited profits were extremely small, but that was only to be expected of a new company – it would not even have been particularly surprising if it had made small losses instead.

Then, after some time, the parent company began to notice that Jim's overdraft had grown and grown. The bank allowed it to do that because the parent company guaranteed it. That is why no serious alarm bells had so far rung, but now the figures had grown so large that they gave serious concern. As luck would have it, the parent company's MD had had a heart by-pass operation, and was off work for a long time. So no one from the parent company had visited for a while, and no one could be spared to look into the affair. An outside management consultant was engaged to do so.

He realised at once that something was very wrong, but it took him some time to discover the full extent of the problem. When he reported back he said: "When I opened this can of worms, the worms just kept on and on flowing out. There is no way they could ever be stuffed back into the can". The deficit which Jim's company had incurred was so much worse than at first appeared that it very nearly pulled the parent company down with it.

The disaster was due to Jim's energy and optimism. He took on more and more contracts in a technology which was not properly established, and in which no one really had much serious experience. To get the contracts, he had undertaken guarantees of performance, and his installations frequently failed to meet the guarantee. Someone (often Jim himself) then had to return to the site to assess the problem and, as often as not, undertake some remedial work.

Jim would return from these outings and tell his accounts clerk that the cost of the visit and of the remedial work was an extra on the contract, and the client was going to be charged for it. The clerk (who was just that – a clerk, not a qualified accountant) did as she was told. Some of these 'extras' were actually invoiced. The clients insisted that Jim's company should meet its guarantees, so they did not pay them, in which they were perfectly justified. Those 'extras' which were not invoiced were entered in the books as Work in Progress. They therefore appeared in the audit as Trade Creditors, or as Work in Progress, and were classed as Assets. That was how the company's apparent profit was created, and why it had an ever more threatening overdraft.

With better communications between the parent and subsidiary companies, the problem would have been recognised earlier. As it was, the situation became irretrievable.

There isn't much of a lesson to be learned from this, except that a company which operates without a reasonable accountancy system can run into desperate trouble without anyone noticing. In those circumstances too much energy and optimism, plus a measure of self-deception, leads to ruin.

5

GOOD COMPANY

Limited liability

Almost all trade is carried on by organisations which are companies, so it's as well to know what a company is and what it can do.

When people get together to form a trading organisation, they can do so as partners. The drawback to that is that if the partnership fails, each of the partners is liable for all the debt which it has incurred, however great that might be. The idea of a 'Limited Liability Company' originated in the seventeenth century in order to avoid this kind of personal disaster.

The novel idea that you could join a trading venture which did not carry the risk of unlimited losses if it were to fail, was obviously attractive. It seemed to offer a safe way to riches, and a kind of mass hysteria gripped London in 1720. Companies were floated for the most absurd purposes, including the famous one for a project "yet to be revealed". Shareholders found that even their limited losses could bankrupt them. We had another example of mass hysteria in 2001 when investors rushed to buy shares in 'dot.com' companies – i.e. those proposing to use the potential of the internet. Once again, the losses were heavy.

A limited liability company has a 'persona' – that is, in law it is treated as a person, with rights and responsibilities of its own. On the other hand, its backers (now called 'shareholders') are protected from everything except the loss of their original investment.

Every company is run according to its own rule-book, which is called the 'Articles of Association'. These rules can only be changed by a vote at a General Meeting. When a company is first formed, it must have some nominal capital though (as in our case) it can be a very small sum. It may also have shares which have not yet been issued. At any time after that the shareholders can agree to create and issue more shares and sell them, in order to get more capital into the company.

Chapter 6

In a company, the shareholder's own fractions of the company are proportionate to their respective shareholdings, with voting power in proportion. The 'nominal capital' of a limited company is the sum of the nominal face value of its shares. When first issued, the shares must not be sold for less than the nominal value, but they may be sold "at a premium" for more. After that, the nominal value of the share is of little real importance, it can be sold for more, or less than that, or become worthless.

The UK's electricity transmission network was privatised as National Grid plc. It went through some merger deals which caused the accountants to change the nominal value of the shares, as a result of which it is now 11 17/45ths p (eleven and seventeen fortyfifths pence – I'm not kidding!) If the nominal value were important such an absurd value wouldn't be acceptable.

Normally the shareholder can only turn an investment back into cash by selling the shares. If the company has done well, the price should be more than the shareholder paid for it, and vice versa. If the company goes bust, the shares are worthless, but that is the maximum which a shareholder can lose – hence the 'Limited Liability' bit.

People invest in shares in the hope of getting a good dividend, and/or owning shares which can be sold at a profit. On the other hand, the company may not do well, and in that case they will lose out. Shares always carry some risk.

A grim example of the risk in shares: I was Trustee of a Charitable Trust which had quite a lot of cash. Trustees have a duty to invest safely, so we put half of it into shares in Baring Bros – Her Majesty the Queen's personal bank. You could hardly think of a safer-looking investment, but they had a trader called Nick Leeson who misused the bank's lax controls to gamble disastrously on the futures market and effectively bankrupted the company. Its shares became worthless, and were sold to a Dutch bank for £1. The Dutch repaid all the loans but the shareholders got nothing.

Private and public companies

When four colleagues and I set up a contracting company, it was as a 'Private Limited Company'. This describes a company whose shares are not freely available to the public investor and have the letters 'Ltd' after their name. Their Articles of Association contain some set of rules to ensure that the shareholders control who may buy the shares. The commonest of these says that any shareholder who wants to sell shares must find a buyer, agree on the price, and then offer the shares to the existing shareholders at the same price. This is the sort of arrangement which ensures that the shares of a family company can be kept in the family.

It is very hard to value the shares in a Ltd company. The minimum price is what the company would fetch if it were broken up and its assets sold, but if the company is trading successfully, that is obviously much too low. The maximum is – there isn't a maximum. If the prospective buyer wants the shares badly enough, they might pay some absurdly high sum.

I have shares in a small but successful Ltd company with unusual specialised know-how. A huge company in another country (which doesn't have this know-how) is trying to take over the whole business as I am writing this. We would rather stay independent. We wish we knew why the prospective buyers are making their approach. If it is as a straightforward business transaction, we will probably not agree on a price. We suspect, however, that their Government is behind this, which means they may be getting some kind of subsidy, and they might offer a very large sum. Every man has his price…

Companies which are big and well-established enough to get accepted by a stock exchange (and there are fixed rules about that) are called Public Limited Companies ('plc') and their shares can then be sold freely on the open market – that's what a Stock Exchange is for. Britain alone used to have dozens of stock exchanges, but there are only two sizeable ones left: The London Stock Exchange, and the AIM (Alternative Investment Market) exchange.

When Ltd companies have done well and got big enough, they often 'go public' by converting the company to a plc. One object of that is to make it easy for the existing shareholders to sell their shares and so cash in on the progress which the company has made. In any case, the shares usually become worth more if the company becomes a plc, because they are easier to turn into cash. Another objective of going public is that the stock exchange is often used to help the company raise more capital. On the other hand the company loses control over who owns its shares, which can be bought by a competitor. Size isn't everything. The international confectionery firm, Mars, is still a private limited company owned by the Mars family.

Another grim example of risk, this time in Government bonds. My family come from Vienna. My grandfather died at 80, just after the end of World War I. When my father opened the family company's safe he found that the old man, a good patriot of the Austro-Hungarian Empire, had invested every penny he had in Government War Loans. The Austro-Hungarian empire having lost the War and been dismembered, these were now worthless. My father's memoirs record the sour pleasure he got from dropping the loan certificates, one sheet at a time, from the 4th floor window and watching the family fortune flutter into the street below. Moral: nothing is totally safe. (Not even a stockpile of Mars Bars – the rats might get at it.) The important thing is to weigh the risk of any investment, and balance it against the return.

There is no logic in buying shares unless they promise a better return than safer investments like Government bonds and savings accounts, which currently yield about 4–5%.

Most discussion about share prices, etc. is about shares in plcs where the price reflects how the public sees the company's future. Shares in plc companies usually give a poor return purely in terms of dividend. Investors buy their shares if they think there is a prospect of improved future trading, with larger dividends and the possibility of selling the shares at a profit. Shares in private (Ltd) companies have no 'share price' in that sense – each deal has to be negotiated separately.

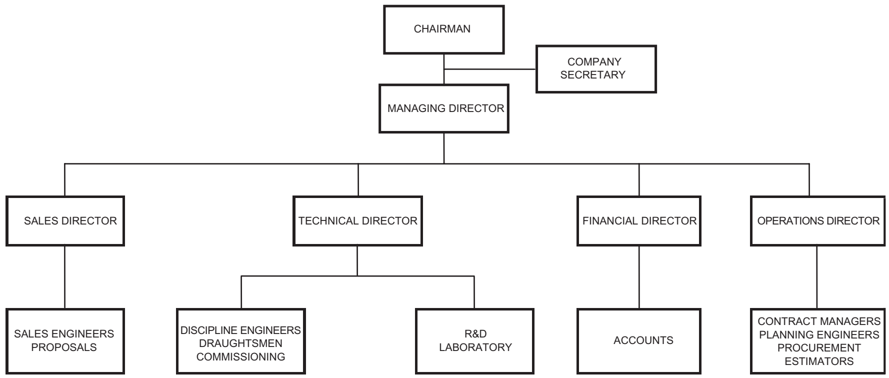
Who runs things?

A company is owned by its shareholders but they have no duties in terms of day-to-day operations. The company is run by a Board of Directors. The directors are theoretically elected by the shareholders to run the business on their behalf, although in practice they tend to be a self perpetuating oligarchy. The Board must present its annual audited accounts to the shareholders, usually with a company report, and convene an Annual General Meeting (AGM). If some major decision has to be made, the Board or a sufficient percentage of shareholders can also convene an 'Extraordinary General Meeting' (EGM). At these meetings the shareholders have the right (but no obligation) to vote on any resolutions put to them. They also vote to appoint or sack individual Directors. If they're really unhappy, they can sack the whole Board. Chapter 3

The directors may also be shareholders but that is not necessarily the case. The Board of Directors is controlled by the Chairman of the Board although decisions are supposed to be made by a majority vote of the directors. The day-to-day running of the company is under the control of the Managing Director or the Chief Executive Officer (CEO).

The directors are 'officers of the company', as is the Company Secretary who may or may not be a member of the Board – often the Finance Director does this job. This person is responsible for making sure that the company stays within the law and maintains proper record books and accounts. There may also be non-executive directors who have no part in the company's day-to-day operation but vote at Board Meetings. They are usually there to represent a major financier like a merchant bank or because of some special influence – MPs frequently take up such positions.

In a medium-sized contracting company, the directors will each have a particular area of responsibility and the company structure may look something like the organisation diagram on the next page.



Share price

Once a company has been formed, the nominal value of the shares becomes unimportant. For buying and selling shares in a plc the share price, like that of anything else, is a function of supply and demand.

A good way of assessing how a plc is seen to perform is the ratio of the share price to the company's earnings per share: this price/earnings ratio is listed in the financial columns as the 'P/E'. The shares in run-of-the-mill companies show a P/E around 12 which is equivalent to a return of 8.5% – i.e. quite a lot more than one could get on a 'safe' investment like Government loans, but as I said, investing in companies always involves some risk.

If the P/E is much lower than 12 – say 9 or less, this means the public thinks the company is not expected to do well in future, so the share price has fallen. By contrast, shares in Smith & Nephew plc have a P/E of over 25. That's because they have excellent technology in artificial knee and hip joints, and as people in developed nations live ever longer, the demand for these replacements must rise. The expectation therefore is that the share price will go up in the future, so it's worth paying over the odds now.

This percentage is not what the shareholder receives annually in terms of dividend – that's usually much smaller because the company will plough back a part of its earnings to increase its capital. When we founded our company we made a policy decision to divide each year's profit (after tax) into three – one to pay staff bonuses, one to the shareholders as dividend, and one to be ploughed back and stay in the company. It seemed both fair and logical.

On the other hand, ploughing profits back into the company adds to its wealth and so the value of the shares will eventually rise and the shareholders will get the benefit.

A paper published in 2000 charted the average P/E in American shares over the twentieth century. It chuntered along at 10 ± 5 for most of the century, but over the final few years rose steadily, and by 2000 it averaged 20. This meant in effect that investment in shares yielded a return of 5%, which – given the risk of failure – is too low. Sure enough, share prices crashed two years later and then settled at a lower and more sustainable level.

Very occasionally the shares of a plc get into the hands of one or a few owners with a sufficiently large majority to entitle them to decide to convert it back into a private limited company. Richard Branson recently did that with Virgin. So did Mr Glazer, who bought up most of the shares in Manchester United Football Club.

The two types of share ownership make a great difference to the character of a company. The Board of a private limited company (or their friends and family) usually own most of the shares, so they are working for themselves. The share price is normally an unknown quantity because no one is buying or selling them, and it is also unimportant. If the company does well, the owners can pay themselves bigger salaries and bigger dividends out of the profits. All such matters are discussed and settled in the privacy of the company itself.

In short, in a private limited company, if the company performs well the directors benefit directly so they concentrate on improving its performance, and that makes a difference to the atmosphere of the whole company.

By comparison, the quoted share price and its daily movements are crucial to a plc. It is not only a measure of the public's confidence, but if investors find the share price falling they may get troublesome at General Meetings. Equally important – the directors are often paid with issues of free shares, so they have a personal interest in jacking up the share price. In a plc, therefore, self-interest motivates the Board to raise the share price by whatever means come to hand. That also makes a difference to the whole company's atmosphere.

That's why the company report which accompanies the annual audit of a plc always contains a fair amount of window dressing. They generally promise a better future, even if that is doubtful. Any statistics of performance over the past years will be carefully selected to start from the most favourable base – that is, the one which shows present performance in the best possible light.

It's an interesting fact that the average tenure of Managing Directorships in big UK plcs is about 3 years. This means that an MD will benefit from making everything look wonderful at the moment when he or she leaves the company: they can sell shares at a high price, get a nice bonus on leaving, and leave a successor to discover that things aren't nearly as rosy as they looked. The successor, in turn …etc. etc.

Shareholders

The Directors of plcs would rather have a large number of small shareholders, than have the voting power concentrated in a few hands – it makes shareholders' rebellions much less likely. When such companies make new share issues, such as I have described, it is usually at an attractive price, to make sure the public takes up all the shares. As a result these issues are normally over-subscribed – that is, there are more offers for shares than there are shares available. The company then creates rules for issuing the shares, by which applicants for small parcels of shares get the number they requested in full, while the bigger ones are progressively scaled down. Result: a large and docile flock of sheep as shareholders, and an easy life for the Board.

There are exceptions to everything, and here is a recent one of a company which reckoned it had too many shareholders. O2 plc was originally created when the nationalised telephone industry was privatised, and all its employees had the chance to buy shares at a very good price. The company took the opportunity of a major reorganisation of its shareholding to offer to buy out a huge number of shareholders with tiny holdings. These might be worth as little as £20: sending all of them the accounts and company reports, and paying them minute dividends twice a year, was uneconomical, the company reckoned.

Summary

- **The Limited Liability Company is the most convenient form for most trading ventures**
- **It starts by setting up its Articles of Association and selling shares**
- **If it's big enough it can apply to a Stock Exchange to become a public limited company (plc), which makes its shares available to the public**
- **Investors buy shares in the expectation of getting a better return than from some safer kind of investment, but take the risk that the company might fail**
- **The share price is important to a plc, but a private company doesn't really have one.**

6

CAPITAL

What is it?

Capital is an accumulated sum of money which is invested for long-term benefit. Money spent on anything else is 'current expenditure'.

> Nature is full of examples of long-term investment – an oak tree labours all summer to produce acorns, which are full of nourishment. That nourishment will help the seedlings to survive, take root, grow, produce more acorns in turn, and so perpetuate the species.

By 'accumulated' I mean that it is somebody's savings. The money may be your own (or a company's own) savings, or your friends' and relatives'. Or it may be borrowed from a bank, in which case they got it by borrowing other people's or companies' savings. Governments can of course appear to create money out of thin air, but to explain that would bring us into the realm of Economics (The Dismal Science) which I avoid like the plague.

'Long-term benefit' seems straightforward enough. Buying a house, for example, is a capital outlay made for the long-term gain of living rent-free. You typically borrow the money from a building society, in the form of a mortgage. The Building Society gets the money from people who put their savings into the Building Society's savings account. Money spent on a holiday is not a capital expenditure – the sun-tan fades quite quickly.

When it comes to small sums, however, there is something of a grey area. A good copier-printer is a capital outlay to a one-man company but petty cash, and therefore classed as current expenditure, for a large one.

These are all my own definitions. They are over-simplified to make things easier to understand and to serve our immediate purpose.

All ventures need capital of two types: Fixed Capital and Working Capital. The easiest way to understand this is to look at a simple example.

What's it for?

Suppose you want to start a newsagent's shop. First you have to pay for the premises (or a lease on the shop), the furnishings, shop window, chest freezer and shop sign. These things are not readily turned back into cash again, so they're called fixed Capital.

Then you need money in the till, and more in the bank for paying wages, bills, etc. You have to buy the stock – papers, magazines, cigarettes, chocolate, and so on, all of which you hope to sell. That's all 'Working Capital', because you hope to turn it into cash soon.

Think of capital as being like a public water supply undertaking – the water works, pipes and pumping stations are fixed capital, and the water in the reservoirs is the working capital. Without the necessary amount of water in the system, the pumps run dry.

Take the most primitive end of the contracting industry as another example – the itinerant builder who knocks on the front door and offers to repair your roof (profit from my experience – these chaps are incompetent at best, and crooks at worst). They need very little capital before they can get any work: they have to buy a few tools, fuel for a battered old van and to keep themselves in food and (more importantly) drink until they get paid for their work. When these builders do get a job, the first thing they do is to demand some money in advance with which the materials needed for the job can be purchased. As our itinerant builder's capital resources are minimal, they have to depend on potential clients to provide it.

This basic form of contracting shows a characteristic which is common to all contracting – it requires little or no fixed capital. Offices, machinery, cars, etc. – can all be rented. Much of the work force is hired for specific contracts – not only the people working on the site, but (for example) freelance draughtsmen might be taken on for each specific job.

However, contracting does need a lot of working capital, because the contractor has to pay employees, buy materials, hire machinery, and so on, while the contract proceeds. The contractor may get paid in stages during the contract, but the payments aren't necessarily big enough and/or early enough to cover all these costs.

Chapter 9

As a typical value, which I will use for various calculations later on, contractors need £1 working capital for every £5 of annual turnover. In practice, of course, this ratio varies between different kinds of contracting, and there is much variation even between companies in the same kind of technology. All other things being equal, the ratio of turnover to working capital is a measure of how effective companies are at managing their affairs.

A company which trades at a rate greater than its working capital is able to support, however, will sooner or later find itself in a squeeze when it can't pay its bills. It might be running profitably, and it might be expecting some large payments quite soon, but neither of those two facts is much help. More of this later.

Chapter 22

Companies must have capital of their own to start with, and if they trade profitably they will keep some of their profit in the company to increase that. In addition, most of them rely on bank loans to supplement that. It means they can achieve a turnover higher than they could sustain using only their own cash.

Most contractors can't offer the banks much in the way of fixed assets to serve as security. Banks want to see fixed assets as a guarantee that they will recover at least some of their loan if the company fails. In case of failure, they reckon logically, the company will have no money left, so there will be nothing with which to repay the loan. But the terms on which the banks grant loans usually give them first rights over all the failed company's assets; and they can sell off any fixed assets to recover at least some of the money they lent.

It's not quite true that banks have first rights to a company's assets. By law the Government has first rights over the remaining assets of a failed company, to recover any tax which the company owes. In fact it is very often the inability to pay their tax bill which pushes companies over the edge.

Another thing: trading when knowingly insolvent is a criminal offence and, if a Board of Directors does that, they are personally liable to go to jail. I can report that when I was in that position for a period of some weeks, I found it a most disagreeable sensation.

Typical manufacturing companies have fixed capital in the form of factories, machinery, warehouses, stock, etc. Because contractors need little fixed capital – everything can be hired or leased – they can produce less security than manufacturers, so banks have to feel very confident of their future before they will lend them a lot of money. The big contractors are considered reasonably secure (though there have been some spectacular failures at that end of the range as well). It is more difficult for smaller contractors to look secure, and therefore many of them find that shortage of working capital limits the turnover which they might otherwise achieve.

Where does it come from?

A company can raise capital either by creating and selling more shares or by borrowing it. Selling shares effectively means selling a part of the company. Shareholders expect to see some return on their money in the form of dividend payments and/or growth in the share price. That doesn't have to happen every year but, overall, shareholders rightly expect a better return from shares than they could have got from putting the money into a safe savings account.

Dividend payments are not directly related to the profit or loss. A generally successful company may suffer a setback in a year and make a loss, but nevertheless decide to keep the shareholders happy by paying the same dividend as the previous year out of accumulated reserves. A company which is struggling to keep its head above water, on the other hand, must keep every penny it can – even if it has made a good profit. As ever, it's all about having enough working capital to keep the organisation working.

Borrowing the money in the form of a loan or overdraft means paying interest whether the company is making a profit or not. Either way it's going to cost the company money. In theory, money raised by selling shares to shareholders costs the company more, but gives it more flexibility than a loan.

Raising capital by selling shares

When a company is first formed, it must have some nominal share capital, though it can be a very small sum. It may also have shares which have not yet been issued. At any time the shareholders can agree, at a General Meeting, to issue more shares and sell them.

Chapter 5

When I and four colleagues started the specialist process plant contracting company which I mentioned earlier, we needed to raise capital. This is what we did – the figures are simplified and should be multiplied by about 3 to allow for inflation since then, but the essence is correct.

What had happened was that the company in which we all worked had been taken over by a nasty and big company. They had made us sign a contract preventing us from taking a job from a list of named companies which effectively covered all the others in our field. This undertaking would probably not have stood up in law, but to avoid having a legal battle we took the easy way and created a new competitor.

We each decided how much we could afford to invest. To avoid the fuss of starting a company from nothing, we bought a dummy limited company. Solicitors set these companies up when they've nothing better to do, and keep them in stock for just this purpose. Its nominal capital was £100, and it had never traded – it was called 'Middle East Trading Co Ltd' – probably for some historical reason. At the time we had no thought of trading in the Middle East, but that didn't matter in the least.

Chris, who was to be our managing director, then sold the idea to a Merchant Bank – that's not a bank where you have your current account, but one whose business consists of making investments of this kind. He managed to make them sufficiently confident of our prospects to put up quite a lot of cash in order to take up shares, so that altogether we had £140,000 with which to start the new company.

We had an Extraordinary General Meeting of the shareholders in the dummy £100 company – i.e. us, plus the man from the Merchant Bank. We appointed ourselves as the Board of Directors, changed the name of the company, and increased the nominal capital. With our £140,000 we could have issued 139,900 new shares at £1 each, but for some reason (which I still don't understand) Chris opted to increase the nominal capital to only £70,000, and had us take up the new £1 shares at £2 each. I myself got 10,000 shares for £20,000 and so had a shareholding which represented 14.2% of the company.

Chapter 5

In accountancy terms it meant that between us we paid in £139,000 of which £70,000 went on the company's Balance Sheet as 'Nominal Capital' and £69,900 as 'Share Premium'. I don't remember how we dealt with the original £100 which (on paper) must have been put up by the solicitors when they founded the company – I'm sure they got us to pay them that sum, plus a lot more for their services. Remember that that this was long ago, so due to continuing inflation since then the sums involved were much bigger than they look now.

Increasing the share capital

Before we continue the story of Chris's company we need to know a little more about shares.

At a General Meeting a company can authorise the creation of a new tranche of shares for sale. If it is a plc this is usually done via a finance company who 'under-writes' the new shares – that is, they guarantee that if the public don't buy them all, they will take up the unsold shares at an agreed minimum price. But if the public takes an optimistic view of the company, the outcome can be very satisfactory for the company.

If a private limited company raises new shares, it is usually for some known purpose, which means there is no doubt that they will be taken up.

I have shares in a company which was formed to invest in technology. It created a large number of 1p nominal shares and went public on AIM. The new shares were under-written at 5p. As it happens, this was at the height of the 'dot.com' craze when shares in companies trading in electronics went berserk. On the day they were issued to the public the quoted share price rose to 55p, but fell to 27p a few days later. Within a few months the whole 'dot.com' craze was shown to be idiotic, and the shares fell to 7p. At least this particular company survived (unlike many other 'dot.coms') and its shares are now back to 12p. Looking at these figures, which of these share prices – 7p, 12p and 55p – could be thought reasonable?

Chapter 4

Eventually Chris's company became insolvent because of the failure of a subsidiary that I described earlier. It was rescued by being taken over, and this is how it worked: The nominal share capital of 70,000 £1 shares was increased to £700,000 by a new issue of 630,000 shares. The rescuer paid £630,000 for them in cash and that got the company out of being insolvent. I still owned my 10,000 original shares, but after that they only represented 1.4% of the company.

Getting capital from loans

So now we had put our company together and raised £140,000. Because the nominal capital was only £70,000 the audited accounts would show this every year as:

Paid-up Capital	£70,000
Share Premium Account	£70,000

We set up a normal current account with a High Street bank (not the Merchant Bank) and paid in our £140,000 (minus what we'd spent in setting up the company).

On my rule of thumb that a contracting company needs £1 of capital for every £5 of turnover, that would have allowed us to aim at a £700,000 turnover, which wasn't enough to stay alive. So we applied to the High Street Bank to give us a loan, which they did. That swelled the working capital we had available, and within a couple of years we had reached a turnover of £2m.

The conditions attached to such loans need a very careful look indeed. For our first loan the Bank insisted that we, the Executive Directors, put up our family homes as security. So much for limited liability!

> Knowing that if you have bad luck you and your family will be put out into the street is a really nasty feeling!

The main point of course is what interest rate is charged on the loan. But loan conditions also specify under what conditions the bank can call in the loan, its normal duration, and how it is to be paid off. Some are repaid in one lump sum at the end of a fixed period (when it is likely that a new loan will have to be agreed). Others are paid off at so much per year. The conditions in which the bank can cancel the loan need a particularly careful look: there have been some awful examples.

> This comes from a recent newspaper report: the bank pulled the rug out from under a successful one-man company because they confused it with one whose name was similar. Without the loan, the poor chap couldn't go on trading and went bust. Then the bank discovered – whoops, sorry – it was all a mistake! Sincerest apologies! The man was ruined, his house had been re-possessed, and his wife had left him. There was no way of restoring his business, even though the bank (generous as ever) offered to restore the loan. But of course, the bank wasn't liable to do more than that – the loan conditions clearly entitled them to call the loan in any time they liked, and that's all they'd done.

Chapter 2

Our chief executive Chris made it his job to butter up the Bank Manager – not a nice man, but fortunately fond of golf. Chris was lavish with invitations to play (followed by lunch). To be fair, though, the bank never let us down and at one time bailed us out in an emergency.

> The title 'Bank Manager' hardly exists any longer: normally the big banks now have staff in centralised offices whose job is to deal with the affairs of client companies over an area wider than that covered by one branch – but I daresay some of them are still quite keen on golf. And it is still a good scheme to do all you can to get them to feel happy about the company's stability.

Why should most companies take out loans at all? Here's a hypothetical example:

> A company with £100,000 nominal capital has taken out no loans but, by ploughing back its profits over the years it has retained £1.9m of profit. This money is reckoned to be the shareholders' property – together with the nominal capital and the share premium account, it makes up the total invested in the company by the shareholders.
>
> Its working capital is therefore £2m, all in 'Shareholders' Funds', so on paper each £1 share represents a £20 investment by its owner. £2m can support a turnover of £10m/year, and at (say) 5% profitability, the company makes a profit of £500,000/year – £5 per share, a return of 25% on the shareholders' funds.
>
> Suppose the company now takes out a £1m loan at 6% interest, and passes the £1m on to the shareholders, at £10 per share. The working capital remains unchanged at £2m, so the company goes on as if nothing had happened, making £500,000 profit on its business, as before. However, it has to pay 6% interest on the loan, which reduces the net profit to £440,000 – £4.40p per share. Now the shareholders' funds are only £1m, but the return on that has gone up to 44% and the shareholder has received £10 per share which can be reinvested.

This sort of logic shows why companies are generally financed by a mix of invested capital and bank loans.

More realistically, in this last example, the return on shareholders' funds was 25% – not bad! Now suppose the company hadn't returned any money to the shareholders but used the loan as an addition to the working capital. If that allowed it to increase its turnover to £15m then, with the same profitability of 25%, the company's profit is £750,000 – £60,000 loan interest = £690,000 – a return of 34.5%. With the increased profit the company will probably pay a proportionally bigger dividend, which should make the shareholders even happier.

This also shows why contracting companies often use a persistent high overdraft to boost their working capital – if they can use it to increase the turnover, the return is normally a lot higher even than the higher interest rate on overdraft.

The important thing is to get the balance between the two of them right. If a company borrows so much on loans that it is crippled by the interest payment, it will go under, like Marconi plc did.

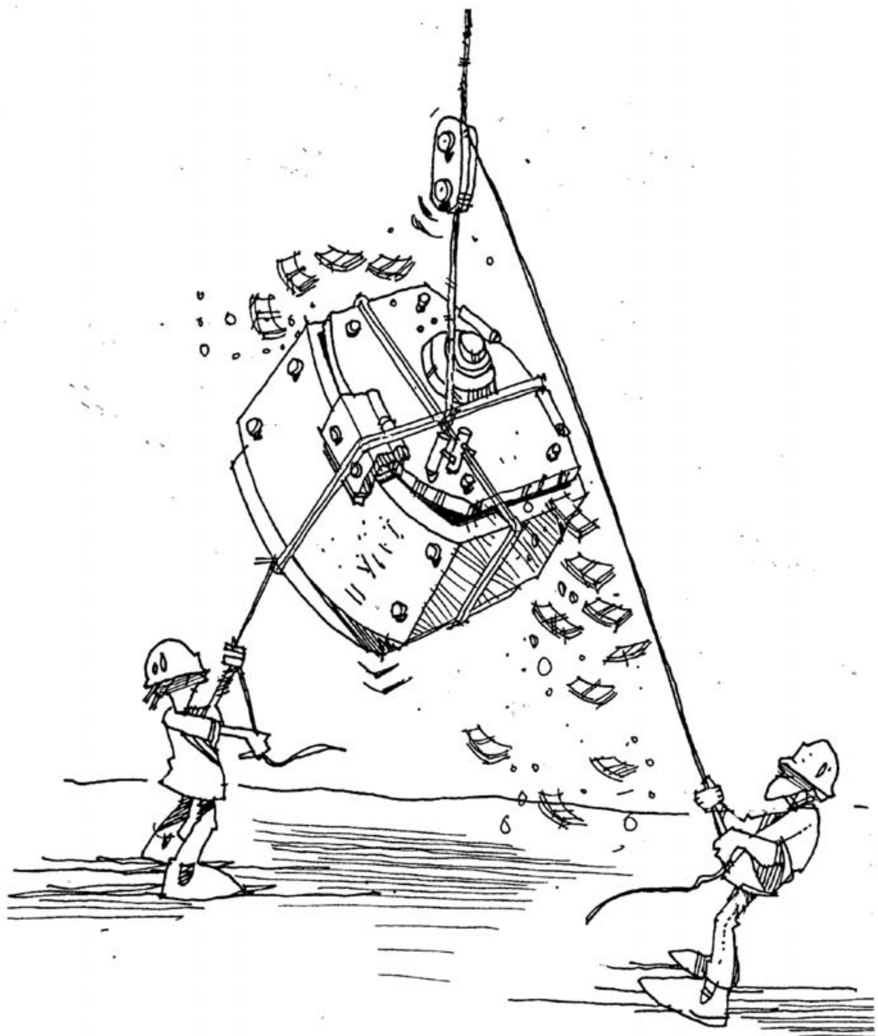


Figure 3 *Raising capital*

Summary

- **To start a business you first have to raise some capital**
- **Contracting needs little fixed capital, but depends on having enough working capital**
- **Companies must take care that their turnover doesn't exceed the level which its working capital will support**
- **Companies with few fixed assets to serve as security have difficulty raising loans**
- **Companies are financed most efficiently by a judicious mix of share capital, accumulated profit, and bank loans.**

7

THE YEAR'S BUSINESS PLAN

How the business works

Now that the necessary capital is in place, we can start to trade, for which we must first plan what we hope to achieve in the year – it's a good trick to ask people what they think is the most important objective when doing that. Most of them will say "To make a profit" and they're wrong. The most important objective is **not to go bust**. As we'll see shortly, it is quite easy to go bust while trading profitably, so making a profit is only the second most important objective.

> Business is like a jungle. In the real jungle every animal wants to procreate, and that is something which you cannot achieve when you're dead. The important moral is that food (or flight) comes before fornication.

Before discussing how the system works, some definitions:

TURNOVER is the year's output, measured by the total amount of sales invoiced (even if the money hasn't been received).

DIRECT COSTS are the costs which are attributable to executing the contracts that the company is working on, such as materials, engineering, site cabins, craneage, subcontracts, project management – the test of whether particular costs are direct is that if the company didn't have this contract, then it wouldn't have these costs.

OVERHEADS are costs which can't be attributed to any contract, such as the accounts department or the receptionist. (Other people use different definitions, but the logic which follows below depends on this one.) Overheads or "Indirect Costs" are sometimes called "fixed Costs", based on the misleading assumption that whatever the turnover, the overheads stay constant. They do nothing of the kind. It's just that over a limited range of turnover they won't change very much.

CONTRIBUTION is what's left of the contract price of a particular contract after the direct costs of that contract have been paid, and which goes into the company's kitty to pay for the company's overheads and profit.

PROFIT is what's left at the end of the company's year, when the company has paid all its direct costs and overheads.

So, taking the totals in a year's trading

TURNOVER minus DIRECT COSTS minus OVERHEADS = PROFIT

Planning for profit

The first thing which becomes clear from this is that a single contract on its own doesn't make a profit. If the sum of the contributions from all the year's contracts (however good some of them might look individually) doesn't cover the overheads, there is no profit.

To plan the year, we must first see how much turnover our working capital and our workforce can sustain, and how much of the market we can command. The smallest of these will set a limit to the turnover for which to plan.

Chapter 6

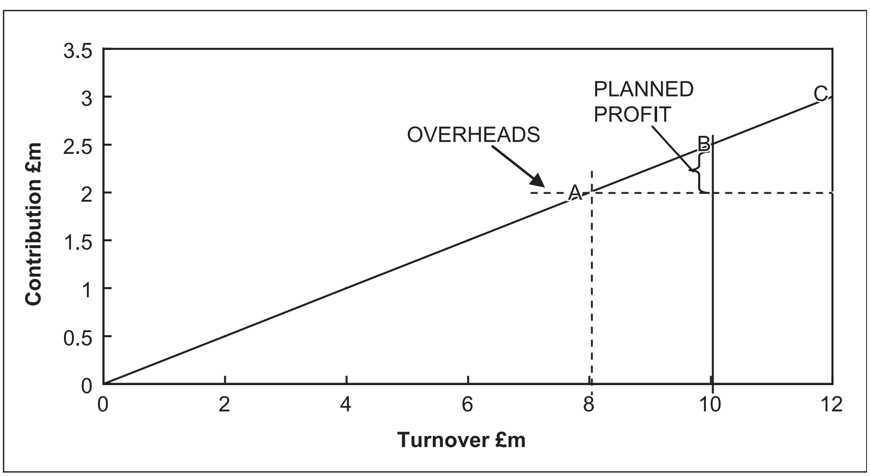
Then we must estimate what our overheads at the lowest of these limitations will be and, from that, what percentage profit our operation can reasonably expect. At one of the earliest Board meetings of our specialist process plant contracting company Chris, who was our managing director, said he wanted us to make 10% profit on turnover. It's not on, I said, no one in this trade makes more than 5%. We tried but, sadly, I was right – we did, just for one year, hit 6%. The reason is not hard to find: Contracting needs very little fixed capital – if it did, we would never have been able to raise enough to get us started. But other groups could (and did) do the same as us, so the competition from new companies was always ferocious. It is said that contracting is the last truly competitive industry there is.

These numbers fix the total contribution which is needed in the year, and the average contribution on all contracts. They might work out like this:

Chapter 3

1	Turnover (T/O)	£10m	that's what you think you can do
2	Direct Costs	£7.5m	That depends on the type of work you are doing, and also on your accountancy system
3	Overheads	£2.0m	you hope that's a good estimate to go with the turnover of £10m and would leave you:
4	Profit	£0.5m	which is 5% on T/O – the most that you thought the market will stand.

To meet this plan, therefore, you need to generate a total of £2.5m in addition to the direct costs of the contracts to cover overheads and profit. (This £2.5m is usually called the 'Gross Profit', which is a rather confusing term so we will avoid it except when we're talking about fiduciary accounts.) That's 25% of the turnover, so each contract the company executes has to aim to make an average contribution which is 25% of its contract price. In practice some will do better and some worse, but that calculated 25% is the target.



The graph above, which illustrates the point, is based on the assumption that all the contracts carry this same percentage contribution, so the contribution increases linearly with turnover. At Point A, when the turnover is £8.0m, the contribution is £2.0m which just covers the overheads but leaves nothing for profit. This point is called the "breakeven point". Point B is the planned performance with a turnover of £10m and a total contribution of £2.5m giving profit of £0.5m after the £2.0m overheads have been paid.

Exceeding the planned turnover by a mere 20% to £12.0m seems to increase the profit by 100% (Point C)! But of course that isn't true. It makes two of our basic assumptions false – first, that overheads remain constant with changing turnover. This is why it is so misleading to call Overheads "Fixed Costs" when, in practice, an increase in turnover would surely mean some increase in overheads.

The second is that the £10m turnover was the maximum which the company can achieve, either because of limitations of the staff and equipment, or because of the working capital available.

Overtrading

Any engineer can quite see that overloading the workforce will lead to mistakes and delays, but may not realise the importance of capital. What they may not foresee is that the company may not have enough working capital to get by. Buying materials, renting machinery, etc., paying extra staff and sub-contractors, all need working capital to finance it. If there isn't enough money available, the moment comes when there's none in the bank to pay the bills, and the company is insolvent.

This pattern is called 'over-trading'. Brilliant young engineers, who have a good idea and set up their own company to exploit it, are particularly likely to fall into this trap. Their idea is so good that the company is profitable and grows. But if they don't realise that it is necessary to increase the working capital to match the turnover, it will sooner or later fail. Some rich old company can then buy it up, pay the outstanding bills, and cash in on the success.

One of my company failures went like that, partly because our Sales Director fell into the error of thinking of overheads as 'Fixed Costs' – that's why I dislike the term so much. It seemed logical to him that, once he had sold enough contracts to meet the planned turnover, we would have paid off the overheads, and the contribution on any further sales would be pure profit. So once he had met the plan, he went on selling more contracts but with a reduced contribution. That allowed him to undercut the competition's prices, and let him make lots of lovely sales.

Other people have told me always to distrust Sales Directors, on principle. Like the culprit in this example, they concentrate their minds so hard on the business of getting contracts, that they ignore little problems like survival and making a profit. This man's predecessor in our company, on the other hand, was really good at his job. His thesis was that any fool can sell at the lowest price. The chap who can sell at a high price is the one who is really good at his job.

For several years running he exceeded the sales target by 10% or more, and after five years we went bust and had to sell the company.

So much for exceeding the plan. *Moral: if it's a good plan, then any serious departure from it can't be good.*

Marginal selling

But what if the sales don't come up to the target? Or if they don't reach even the breakeven turnover? The graph shows that the result is to make the profit fall sharply. Again, if the sales are seriously short, the overheads will probably fall a bit – phone bills will be smaller, employees who leave won't be replaced immediately, and so on. But the fall won't be enough to maintain the profit.

What's to be done? These are now conditions in which one is right to sell contracts with a reduced contribution, which makes it easier to get contracts. That in turn should go nearer to filling the company's capability to do work, which is what the plan was based on. This is called 'marginal selling'.

The logic here is the exact opposite to that proposed by my late colleague, the keen Sales Director. If the company has under-used capacity, then any contribution which can be made from it is better than none.

Suppose you plan a long car journey, and a chap says "You're alone in the car, so give me a lift and I'll pay my share of the fuel". That won't even cover half the real cost of the drive, but if you turn him down you get nothing at all, so you're better off if you take him and his money. Everything is different when there is spare capacity.

Like many Process Plant contractors, we had teams of Erection and of Commissioning Engineers. Their jobs were, respectively, to get the equipment erected and installed, and then start it operating well enough to get past its acceptance test. These are highly skilled people – once you've got a good team you don't let them go. So on the many occasions when our work schedule didn't have any work for them, we would offer their services to other companies cheaply, at what were (on paper) uneconomical rates. The cut price meant we could usually procure work for them, and that brought us in some contribution instead of none.

SUMMARY

- **A company needs a plan for the year in order to achieve its maximum potential**
- **The plan has to set targets for turnover, overheads and profit**
- **If the actual turnover significantly exceeds that planned, the company may get into trouble**
- **If it looks unlikely that the target turnover will be reached, marginal selling (by cutting the contribution on contracts) can be a useful partial remedy.**

8

HOW NOT TO GO BUST

The need for working capital

There is only one way in which companies fail – by not having money with which to pay their bills. That happens if their working capital has run out: whether they are making a profit or not has little directly to do with that.

It's important to understand that turnover is not the most important thing for the company. If that turnover isn't profitable there's going to be a problem. I once worked for a Managing Director who had been a salesman. Before a tender was submitted the managers would have a meeting to discuss and agree the price that we would offer. The price make-up sheet had, as part of the contribution to company overheads, a notional profit of 2½%. Given the opportunity our Managing Director would try to see the Client after submission of the price and would almost invariably offer him a 10% discount. In vain I tried to point out that this meant that most of the contracts we won would make a 7½% loss (unless the contract manager was clever enough to find a way of making savings). He was happy that the company's turnover was increasing year by year. Sadly the company went bust because of poor profitability but with a full order book.

The amount of Working Capital which companies need, measured as a percentage of the turnover, varies a lot between different types of industry and even between different companies in the same industry. It seems as if each company's circumstances dictate how much is needed, so that the figure for any individual company tends to remain fairly constant, however much the turnover rises or falls. Typically, contracting companies might need working capital equivalent to a fifth of their turnover. Whatever the percentage, it is the amount which gives the company enough flexibility to survive normal trading fluctuations.

Here are some ways how this works, based on the £10m turnover company which we have previously used as an example.

Case 1

In one year, the company makes a loss of 2% on turnover – i.e. a loss of £200k. This reduces its working capital to £1.8m – i.e. by 10%. That will not make a massive difference to next year's trading when, with luck, business will be better, the loss recouped and the working capital restored. A modest and occasional loss doesn't bring a healthy company down.

> My wife inherited shares in a family company making expensive cloth at an ancient factory in a small town in Somerset. Around 1900 it was very profitable, but by 1950 Somerset had become the wrong location for this trade. The family were kindly people: they never sacked anyone because there was no other employment to be had locally. For years the company's annual audit showed a loss, which it survived because it owned a lot of land locally (fixed capital) which could be sold to make more money available for working capital. In the (inevitable) end it ran out of saleable bits of Somerset and became insolvent.

Case 2

The Company has a major contract worth £3m, and there is a problem which delays a part payment of £1m. The company still has £1m of working capital with which to carry on and, if the delay is not too long, it ought to survive. The most obvious action is to go to the bank for extra finance, such as a temporary increase in its overdraft limit, especially if the cash crisis is expected to be short term.

Case 3

The company is working on two contracts each worth £3m. Both these suffer some setback: a payment of £1m is delayed on each, which reduces the working capital to zero. Unless cash can somehow be raised quickly the company cannot pay its bills and is insolvent.

This can happen as easily to a company which is making a profit as one running at a loss, but in practice there is a big difference. If a company commands the bank's confidence, the bank is more likely to help the company out of trouble.

Chapter 6

This shows that companies must not take on contracts so big that a serious setback on them can break the company. In the fatal Case 3, the troublesome contracts are indeed only 30% of the turnover each, but with two of them in trouble that's enough to bring the company down.

Our company avoided tendering for contracts so big that they could sink us, and this works both ways – clients don't want to employ contractors who might go bust while halfway through the job.

Large companies, like for example the petrochemical giants, have lists of potential contractors who are considered fit to bid for jobs. These lists show the maximum value of contracts for which they should be considered. Contractors who have grown since getting on to one of these lists, have quite a struggle to get promoted into a bigger league.

What's to be done, though, by a contractor threatened with being awarded a contract so big that they shouldn't really take it on? For example, suppose that while a contractor is negotiating a contract near their size limit, the client increases the size of the project. If the contractor lands the contract he or she runs two risks: one, that the company can't cope physically – not enough manpower, machinery, etc. – the other, that it hasn't got the working capital.

The first danger is obvious enough, and so is what ought to be done to overcome it. Unfortunately the money problem is easy to ignore – especially by engineers who aren't supposed to know about money. At a moment when everyone is licking their chops at the prospect of getting a great chunk of work, it's easy for them to think, "Oh, don't worry, it'll be OK".

The best-planned jobs can come unstuck. There's always risk of trouble and delay by things like weather, strikes and accidents. With a small contract, that's a nuisance. With a very big contract, it can break the company. (Of course 'small' and 'big' is relative to how big the contractor is.)

Our company had a big contract for a Cuban sugar mill, at the height of the Cold War, when communist Cuba was practically cut off from the western world. We were to be paid CIF (cost, insurance and freight). We hadn't realised that at that time there were only three boats a year to Cuba, and we just missed one. The entire consignment, all crated up, spent months sitting at Tilbury docks. We'd had the cost of producing it, and hadn't been paid a penny. Result, a cash flow crisis.

The bank was shown the detail, so they knew that we would get paid within a few months. Anyway, we'd always taken a lot of trouble to ensure they knew (or thought they knew) what a splendid and reliable outfit we were. So they increased our overdraft limit – at their usual high interest rate, of course – and when the next ship came in we were out of trouble.

Chapter 18

That kind of disaster can happen as easily to a company which is making a profit as one running at a loss.

Summary

- **Companies fail if they run out of working capital**
- **Small, temporary losses are not usually fatal**
- **A company must not take on contracts which are so large that they could cause it to fail.**

9

CASH FLOW

What's cash flow?

It boils down to this: to stay alive, a company must always have enough money to pay its bills. It must therefore regulate the flow of money in and out, to reduce the risk of running out of cash. If we go back to the tank analogy that I introduce in Appendix 1, it's all about controlling the flows into and out of the tank to ensure that there's always something in the tank. Control of Cash flow is probably the most important aspect of running any commercial venture and, in the contracting business, it's the job of the contract manager.

Appendix 1

The monthly bank statement of your personal current account shows how your cash flow has gone, with sums of money coming in, payments going out, and the daily balance during the month. A company's bank statement does the same.

In a contracting company the outgoings are of two kinds – a fairly steady flow of the regular costs in running the company – paying salaries, rent, and so on. Most of the money, however, goes out irregularly and sometimes in very large chunks – these are for the materials and services needed to carry out its work. Payment coming in is similar in that it tends to be in irregular, large sums, received for work as it is completed. The monthly balance goes up and down and can be shown as a table or a graph. Let's look at an example to see how this works. Suppose we have a contract valued at £1.868m with the price made up as given in the example on the next page.

Chapter 14

The table rather nicely demonstrates the curse of the computer: the estimates are all given to the nearest £100 (and that is probably more accurate than the facts justify). When the percentage additions are made, the spreadsheet calculates them to the nearest £1 and that is how the price is presented which is, of course, absurd.

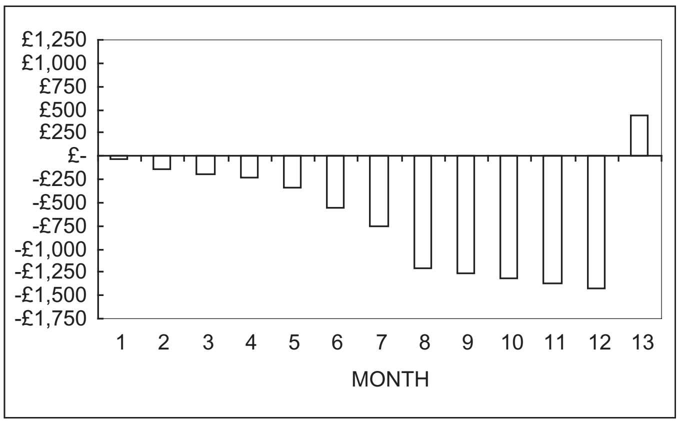
Chapter 24

CONTRACT PRICE MAKE-UP SHEET

			£	£	**£**
Mate rials	mechanical			440000	
	electrical			250000	
	control &			100000	
	instrumentation				
	deliveries			10000	
	Sub Total				**800,000**
Installation	mechanical sub			50000	
	contract				
	electrical			30000	
	subcontract				
	Sub Total				**80,000**
Engineering	process	300 hrs	@ 35.00/h	10500	
	mechanical	650 hrs	@ 30.00/h	19500	
	electrical	450 hrs	@ 30.00/h	13500	
	controls	400 hrs	@ 35.00/h	14000	
	drawing	500 hrs	@ 25.00/h	12500	
	commissioning	250 hrs	@ 40.00/h	1000	
	Sub Total				**80,000**
Management	manager	2000	@ 40.00/h	80000	
		hrs			
	procurement	500 hrs	@ 30.00/h	15000	
	QA	300 hrs	@ 30.00/h	9000	
	safety	400 hrs	@ 40.00/h	16000	
	Sub Total				**120,000**
Site	offices	50	@ 200.00/week		
		weeks			
	craneage	200	@ 200.00/day		
		days			
	support staff	8000	@ 15.00/h		
		hrs			
	telephone				
	stationery/printing				
	transport				
	Sub total				**200000**
Finance/	interest	2.0% of Contract Price		37373	
Miscellaneous	agent's fees	1.0% of Contract Price		18686	
	fixed price	2.0% of Contract Price		37372	
	licence fees	0.5% of Contract Price		9343	
	insurances	1.0% of Contract Price		18686	
	Sub Total				**121,460**
Total direct costs					**1,401,460**
Contribution		**25% of Contract Price**			**467,153**
Contingency					**0**
CONTRACT PRICE					**1,868,613**

Now let's assume, initially, that we get paid in a single payment on completion of the contract. The contract is completed in 12 months so, allowing for the month's delay between invoice and cheque, that means we get paid in full in month 13. The cash flow looks like the table on the following page.

For simplicity the interest for each month is calculated on the previous month's overdraft. That's not exactly right because the bank calculates interest in a daily basis, but it makes the spreadsheet easier. We can show this as a graph.



The money left in the bank at the end of the contract is the contribution plus contingency, in this case £430,735 or 23% of the contract price. That's 2% less than we planned for in the price make-up sheet. Now a 2% reduction in contribution doesn't sound very serious, but it is. If the overall profitability of the company's contracts is 4% then it represents half the profit. Some sectors of the construction industry operate on even lower profit margins and, for them, the loss is correspondingly even more serious.

What does this tell us?

The two important things to look for on the cash flow graph are: how great are the peak variations (plus and minus) from the average balance over a long period, and what is the average balance over a long period.

Looking first at the variations, if the account is in credit most of the time, it suggests that the company is not using its working capital to the best advantage. On the face of it the company has cash lying around which is not doing

MONTH	1	2	3	4	5	6	7
Opening balance	0	-30000	-144338	-195540	-237170	-349146	-552056
Payment received							
Total receipts	0	0	0	0	0	0	0
Site establishment		10000	20000	20000	20000	20000	2000
Project management	10000	20000	10000	10000	10000	10000	10000
Engineering	20000		20000	10000			
Equipment supply					80000	16000	160000
Installation						10000	10000
Commissioning							
Miscellaneous		84088					
Interest at 10%		250	1203	1630	1976	2910	4600
Total costs	30000	114338	51203	41630	111976	202910	204600
Closing balance	-30000	-144338	-195540	-237170	-349146	-552056	-756656

MONTH	8	9	10	11	12	13	TOTAL
Opening balance	-756656	-1202962	-12629876	-1323511	-1374541	-1425995	
Payment received						1868613	1868613
Total receipts	0	0	0	0	0	1868613	1868613
Site establishment	20000	20000	20000	20000	20000		200000
Project management	10000	10000	10000	10000	10000		120000
Engineering							70000
Equipment supply	400000						800000
Installation	10000	20000	20000	10000			80000
Commissioning					10000		10000
Miscellaneous							84088
Interest at 10%	6305	10025	1035	11029	11455	11883	73791
Total costs	446305	60025	60525	51029	51455	11883	1437878
Closing balance	-1202962	-1262986	-1323511	-1374541	-1425995	430735	430735

any real work. If the company can't use it, the shareholders should get it as dividend.

Having said that, if a company knows it is going to have spare cash just for a few months, it should at least invest the surplus on a short-term basis and get the benefit of the interest which that can bring in.

> Our company had a period when we had a lot of cash in the bank. We put the surplus into local authority loans for a few months and the interest we got from that accounted for a quarter of that year's profit. (That's not surprising if you remember that in contracting the profitability – that is the profit as a percentage of turnover – tends to be very thin.) But it didn't take long before things reverted to normal and we were in overdraft again.

If the minus variations are regularly near the overdraft limit, the company is living dangerously. Either it isn't managing its cash flow very well, or it needs more capital, or both.

As to the average balance, the important thing is that the datum is not necessarily fixed. If a company is heavily into overdraft most of the time, and the bank can be persuaded into giving it a loan, that would shift the datum. Unless the bank reduces the overdraft limit, that shifts the average value and boosts the working capital. Interest on loans is lower than on overdraft, so it is better to finance a company by loans than overdraft.

In practice, though, most companies are in overdraft most of the time. The logic is quite simple. Our earlier example showed a modestly successful contractor making a profit which is 25% of the working capital. As that return is far greater than any overdraft interest rate, it's sensible to use as much of the available overdraft as is safe to boost the working capital. The danger is that it reduces the safety margin which the overdraft facility gives, so it is important not to push it too far. Chapter 7

It's also important to avoid violent variations – as long as that is possible. A high credit balance for a short period feels nice but is useless. Large overdrafts are dangerous if they get near or beyond the limit set by the bank. Management of the cash flow should aim at getting the incomings and outgoings to balance one another, so keeping the swings to a minimum.

Better still, of course, is to get all payments to come in as early as possible, and pay out as late as possible.

Progress payments

Any contract for a project sets down how much the client will pay the contractor, and when. If you have a plumber carry out some minor work in your house, you expect to pay the full amount when the job is finished. Commission a complete new kitchen, and you will have to pay a sizeable fraction of the contract price before work on the kitchen can begin – that's because the contractor in turn has to order and pay for the new cooker and units, etc.

The bigger the project, the more important this becomes. Obviously if a contractor, with a working capital one-fifth of turnover, had to pay the full cost of completing the projects before any money has come, they would run out of cash within a few months. There is an obvious conflict of interest here: the contractor wants to get paid as early as possible, while his or her client (who is also minding their cash flow) wants to delay shelling out as long as possible. What payments are to be made on a contract, and when, are therefore a vital part of the original contract agreement. We'll get back to them later.

Chapter 18

Once the terms of payment are fixed by the contract, and the points at which payment will be made become clear, one of the contractor's main aims is to reach them as quickly as possible. That needs good planning and can often mean spending extra money. The whole company, and particularly the engineers and the management accountants, must work closely together to make the best of this task.

Chapter 20

On larger jobs we often had a contract which gave us a first payment (typically 15% of the contract price) on delivery of the engineering drawings or other documentation. As soon as the order was confirmed, therefore, the Engineering Department began to work flat out, possibly putting people on overtime or engaging freelance engineers to speed the work. When the complete drawings were ready they would be sent by e-mail to save a day. Of course, there's no need for the contractor to have the complete set of drawings ready at the start of a contract, and the additional effort to get them done costs extra. But getting paid a large sum early makes it all worth while.

Now let's assume that our contract has terms of payment that give us stage payments as follows:

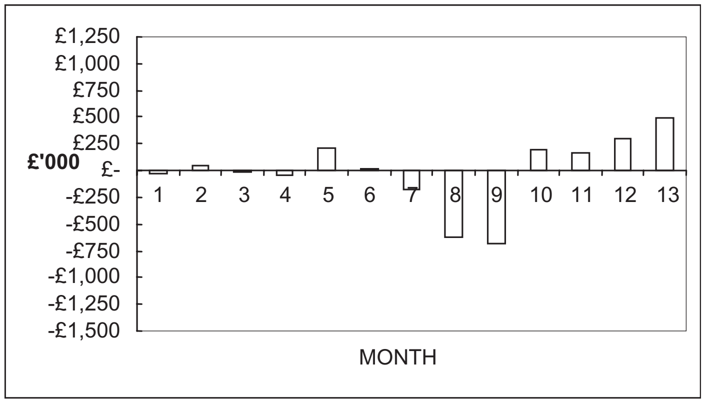
10%	With order
20%	On approval of drawings
50%	On delivery of all equipment
10%	On completion of installation
10%	On completion of commissioning

That gives a completely different cash flow as in the example on the next page.

MONTH	1	2	3	4	5	6	7
Opening balance	0	-30000	42524	-7476	-47539	215788	15788
Payment received	0	186861	0	0	373723	0	0
Total receipts	0	186861	0	0	373723	0	0
Site establishment			20000	20000	20000	20000	20000
Project management	10000	10000	10000	10000	10000	10000	10000
Engineering	20000	20000	20000	10000			
Equipment supply					80000	160000	160000
Installation						10000	10000
Commissioning							
Miscellaneous		84088					
Interest at 10%		250	0	62	360	0	0
Total costs	30000	114338	50000	40062	110396	200000	20000
Closing balance	-30000	42524	-7476	-47539	215788	15788	-184212

MONTH	8	9	10	11	12	13	TOTAL
Opening balance	-184212	-625747	-680962	197670	157670	304531	
Payment received	0	0	934307	0	186861	186861	1868613
Total receipts	0	0	934307	0	186861		1868613
Site establishment	20000	20000	20000	20000	20000		20000
Project management	10000	10000	10000	10000	10000		120000
Engineering							70000
Equipment supply	400000						800000
Installation	10000	20000	20000	10000			80000
Commissioning					10000		10000
Miscellaneous							84088
Interest at 10%	1535	5215	5675	0	0	0	13133
Total costs	441535	55215	55675	40000	40000	0	1377220
Closing balance	-625747	-680962	197670	157670	304531	491393	491393

And the graph looks like this:



Better still, the contribution and contingency has increased to £491,393 or 26%, which is better than we anticipated.

So cash flow and, in particular, terms of payment, are important to the company's profitability. It's part of the contract manager's job to control that cash flow.

Retentions

Chapter 18

Sometimes terms of payment include a 'retention' which is a part of the contract price (usually 5 or 10%) which the purchaser retains (i.e. doesn't pay to the contractor) for a period of six or twelve months after completion of the contract. The contractor gets money after this time only if the purchaser is satisfied with the job. The theory is that, if the contractor hasn't been paid in full they will be much more likely to take post-contract responsibilities (carrying out any rectification work and making good any latent defects) more seriously.

The original concept was that the retention would represent the contractor's profit and this would be an incentive for them to perform. These days, of course, with profit margins greatly reduced, a 10% retention represents a significant part of the contribution on a contract and waiting for it for twelve months can be a serious cash flow problem. At the very least, the contractor will probably need to borrow money to cover the retention and this will increase the interest charges.

Paying late

The best way of improving cash flow is by paying as late as possible, and that is achieved by good planning and skilled purchasing. Goods and services should arrive when wanted and not before, so that the invoices for them only become due at the latest possible time in the project's programme.

The normal rule for invoices is that payment is due one month after the date of the invoice (sometimes it's a calendar month, sometimes 28 days). Paying invoices later than that can be done legally, or illegally. One legal way is for the contractor to agree some longer period of credit with suppliers – this is called 'Supplier Credit'. A civil engineering contractor, for example, is likely to need a lot of concrete. An agreement that he or she will not buy the stuff from any other competitor can be made with one particular supplier: in exchange for that the supplier agrees to give two, or even three months, grace before the invoices need to be settled.

The illegal way is all too common: the company simply doesn't pay its bills on time. Many smallish businesses have at one time or another been so short of cash that they deliberately sit on invoices even though they are due. The Chief Accountant confers with the MD to decide which of the bills they really have to pay now – because failure to pay would upset an important supplier, for example – and which creditors can safely be left to wait for their money.

> A Chinese student who had worked in a Chinese restaurant in New York told me that they had acquired a reputation for being rotten payers. When their suppliers got fed up with this, they simply sent the restaurant rotten food.

Occasional events like this would be tolerable, but in recent times late payment has become systematic – the rot started in the 1970s, with large private and even some nationalised industries making late payment their policy. The Central Electrical Generating Board, for example, ran all UK power stations: for some types of equipment they were almost monopoly customers, and could afford to ill-treat their suppliers with impunity. When such big clients decided to pay late, their suppliers ran short of cash and couldn't pay their bills, and so on down the chain. No one dared to take their clients to law for their money for fear of offending a vital customer; anyway the process of recovering the debt would have taken so long and cost so much, that it would have been suicide. The Government has since passed legislation which imposes quite heavy interest charges on unpaid invoices, but its effect has been nil, for the same reasons.

Readers of P.G. Wodehouse novels will know that in his time the young gentlemen at Oxford and Cambridge would run up tailors' bills for their whole 3 or 4-year stay, which they weren't expected to pay before they'd inherited the family fortune.

At that time traditional industries were financially so well provided that they would not consider cash flow very important. In 1968 I worked on a contract which we undertook jointly with a Dutch company. Some months after the contract was completed and the books closed, we were embarrassed to receive an invoice for painting – the Dutch sub-contractor was still in the habit of only sending out his invoices at the end of the year.

It may sound silly, but I suspect that the concept of managing the cash flow and its importance had only just begun to trickle through to the engineering industry, and when it began to take hold, the people in charge over-played their hands. They didn't realise how much harm that would do to the entire industry.

Late payment became a national disease, and a lot of small companies went to the wall because of the trickle-down effect – not through mismanagement on their part, but because they were helpless victims of the big organisations' refusal to pay on time.

In desperation, a company can get paid most of the money which is owed by 'factoring out' the debts to professional debt-collectors. This maintains the cash flow, but loses a crucial percentage of the total sum.

What means the debt factors use to collect the money I don't know. But I was once asked to call on a client's offices which happened to be on my way home. They owed us a large sum and our accountant had been told "The cheque is on the MD's desk, sir" – clearly it had been put on the "let 'em-wait" pile. "Can I make myself as disagreeable as I like?" I asked, "yes" was the answer.

It was a Friday evening. Their office was a small high-rise block, with a basement car park. I parked my car blocking the ramp down to it, and went up to the company secretary's office. "I've come to collect our cheque," I told him, "which we're told is on your MD's desk. And, by the way, I seem to have parked across the exit to your car park, so until I've got it, nobody is going to be able to go home".

It was perfectly true. The cheque must have been on the MD's desk, because I drove off with it in my pocket a few minutes later.

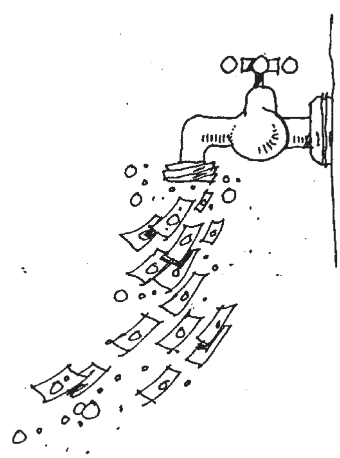


Figure 4 *Cash flow*

Summary

- **Contracts and companies must be run in such a way that they don't run out of cash**
- **This means predicting and managing the flow of money in and out**
- **On contracts of any serious size, there is usually some agreement for progress payments by the purchaser as work proceeds**
- **The amount and timing of these progress payments are crucial**
- **As well as the danger of running out of cash, not getting paid for work means having to borrow more, and that means increased interest payments which slash profits**
- **Illegal late payment is rife and causes serious problems.**

10

WHAT'S A CONTRACT?

An apology

Sorry, but some of the stuff in the next few chapters is 'legalese' and can become quite boring unless you've got the sort of mind that soaks up the odd bit of Latin. But bear with me, it's worth it – you'll be able to baffle the opposition!

To start off the legal bit, we need to know what law governs the contract so that we can understand how things are interpreted. We'll be talking about English Law, which applies only in England, Wales, Northern Ireland, the Channel Islands and a number of former dependencies like the West Indies and Singapore who have chosen to retain it. Scottish Law differs in some respects and laws of other countries may vary quite widely. This is obviously very important when we're dealing with export contracts which involve supplying equipment and/or construction services overseas, and that's why contracts usually specify which country's laws will rule in any dispute.

It's an Agreement

An 'agreement' occurs when the parties discussing or negotiating an arrangement between them have reached an identical conclusion – the legal expression is 'ad idem' (I warned you about the Latin). A contract is an agreement between two (or more) parties which is enforceable in law, provided that certain conditions are observed. As far as we are concerned as engineers, a contract is almost always a promise by one party (the contractor) to supply certain goods (for example, equipment such as pumps and valves) and/or services (for example, design, construction or installation) in return for payment of money by the other party (the purchaser or the Client – we'll use these two terms interchangeably).

For a contract to be valid the following elements are necessary:

- There must have been communications between the parties showing their intention to deal with one another – these are called 'offer' and 'acceptance'.
- The parties must be legally capable of contracting (e.g. companies must be incorporated).
- There must be a 'consideration' or a 'quid pro quo', which means that the purchaser must promise to remunerate the contractor for executing the contract.
- There must be a written form of contract (this is not strictly true for all types of contract but, because engineering contracts are complicated it is the rule as far as we are concerned).
- The contract must be legal. That is, the objective of the contract must not be forbidden by law (you can't employ a contractor to rob a bank).

> As Samuel Goldwyn, the famous film producer, once said "A verbal contract isn't worth the paper it's written on".

> If you employed a contract assassin to kill your boss and they failed to do it, you couldn't sue them for breach of contract. The contract would be invalid because the objective was illegal. You might find yourself in all sorts of other trouble, too.

- It must not be impossible to achieve the object of the contract. The contract becomes void if, for example, something comes to light in the course of the contract which makes it impossible to carry out certain work, and which neither of the contracting parties was aware of at the time of contracting.

> An example might be the laying of a pipeline across land for which way leave, initially promised, is subsequently withheld.

- the consent of the contracting parties must be genuine, that is not marred by mistake, misrepresentation or fraud.

For an agreement to exist between the two parties there must be an understanding of what has been agreed to, and this understanding must be demonstrable. This is the purpose of the 'contract documents'. These are usually presented in the form of a 'Tender Document', which is issued by the purchaser to set out exactly what goods and/or services the contractor is to supply (the technical section) and the terms and conditions which are to be imposed on the contractor (the commercial section). In practice this is not always as easy as it sounds.

How engineering projects happen

It's quite hard to define a 'Project' properly, but for our purposes it is some sizeable undertaking to build or produce something durable. It might be a road bridge, or a sugar mill, or a reservoir, or an oil pipeline. The project is commissioned by the Client and executed by the contractor.

There is a simple logical sequence for bringing this about. Have a look at the flow diagram on the next page. If only real life were like that!

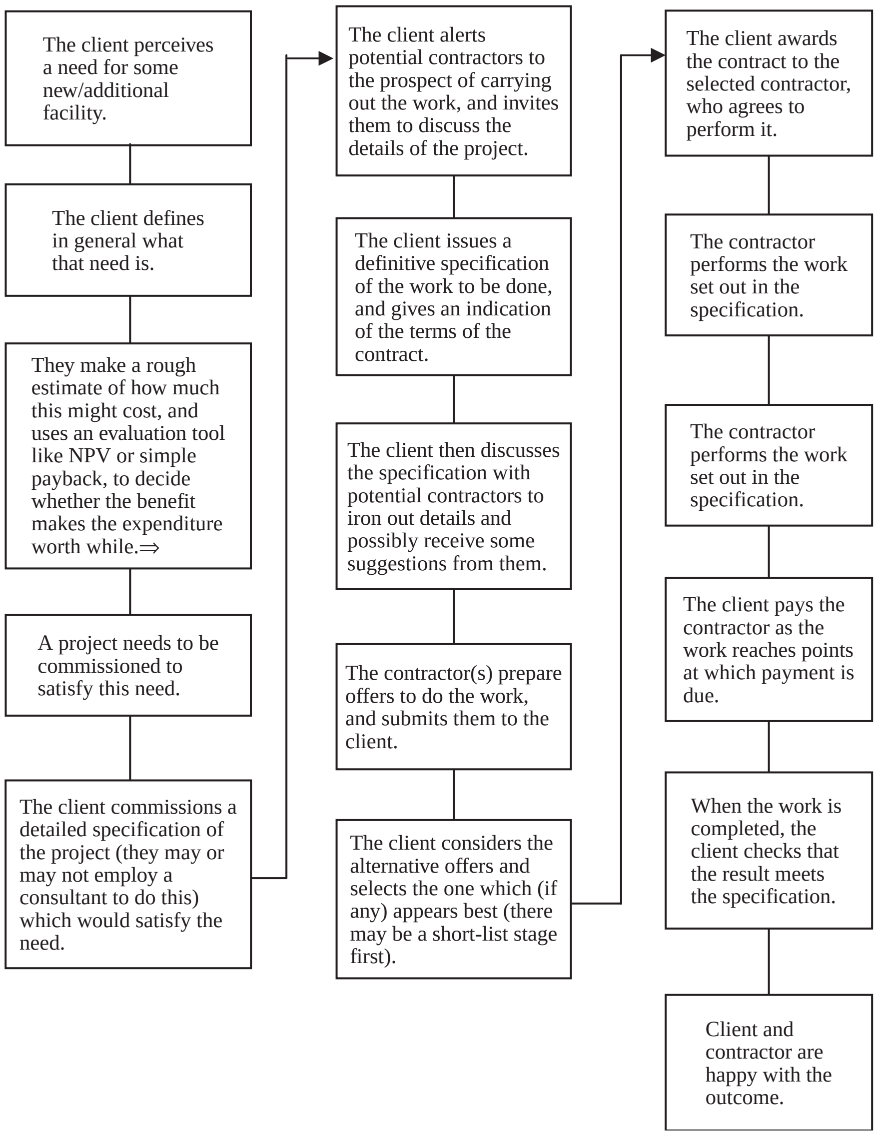
In reality, there are always some projects which are allowed to proceed without some of these jobs having been performed properly or even at all, and that often means trouble.

Tender documents

Tender documents vary enormously depending on the industry, the type and size of contract, whether it is a 'greenfield' project or modifications to an existing plant and who has prepared them. Tender documents prepared by civil engineers tend to concentrate on general specifications and priced bills to allow 're-measurement' (re-measurement is done by quantity surveyors). In the chemical industry the documents are more often prepared by process engineers who are more concerned with process performance and lump sum prices.

Tender documents prepared by consultants frequently contain large amounts of irrelevant material designed to 'pad out' the documents. This is because many consultants believe that their worth is reflected in the thickness of the documentation which they produce rather than the information which it contains. Often this belief is justified.

The thickness of tender documents used to be used as a quick guide to the contract price, at about £10,000/mm but, over recent years, this has proved unreliable.


The client perceives a need for some new/additional facility.
The client defines in general what that need is.
They make a rough estimate of how much this might cost, and uses an evaluation tool like NPV or simple payback, to decide whether the benefit makes the expenditure worth while.⇒
A project needs to be commissioned to satisfy this need.
The client commissions a detailed specification of the project (they may or may not employ a consultant to do this) which would satisfy the need.
The client alerts potential contractors to the prospect of carrying out the work, and invites them to discuss the details of the project.
The client issues a definitive specification of the work to be done, and gives an indication of the terms of the contract.
The client then discusses the specification with potential contractors to iron out details and possibly receive some suggestions from them.
The contractor(s) prepare offers to do the work, and submits them to the client.
The client considers the alternative offers and selects the one which (if any) appears best (there may be a short-list stage first).
The client awards the contract to the selected contractor, who agrees to perform it.
The contractor performs the work set out in the specification.
The contractor performs the work set out in the specification.
The client pays the contractor as the work reaches points at which payment is due.
When the work is completed, the client checks that the result meets the specification.
Client and contractor are happy with the outcome.

Whilst it is difficult to generalise, most tender documents will contain at least some of the following sections (in no particular order):

Scope of Work	This should define the work to be executed under the contract and should provide background details such as why the work is to be done and what impact other associated contracts might have on the work.
Particular Specification	This section (usually the most important for the proposals engineer) sets out specifications for processes and equipment to be used on the project. It may consist of a simple performance specification (e.g. guaranteed quantity and quality of product), a 'design and build' specification which details the process route to be used but not the detailed design, or a 'detailed specification' which gives all dimensions for structures and provides a shopping list of equipment to be procured, installed and commissioned by the contractor, usually in the form of 'bills of materials'.
Nominated suppliers	Sometimes a purchaser will wish to nominate a particular supplier for certain items of equipment (e.g. pumps) in order to standardise on spares and servicing. 'Nominating' a supplier can mean contractual problems, because a contractor cannot be held liable for any delays or defects which are the cause of a nominated supplier or subcontractor. For this reason purchasers often issue a list of 'preferred vendors'. Whilst this is not mandatory, the contractor's alternatives may not be accepted by the purchaser, and the contractor who ignores preferred suppliers in favour of a cheaper alternative may find themselves forced into providing the more expensive preferred equipment at their own cost.
General Specification	This section will provide copies of the purchaser's standard specifications for equipment, paint finishes, materials and so on and should be examined for clauses such as "pump motors shall be 1450 rpm" which may increase the cost of equipment, often for no particularly good reason.

Programme Usually the contractor will be required to submit a proposed programme for contract execution, but sometimes the purchaser will issue a programme for the works and the contractor must establish if this is reasonable (the Completion Date is defined by cynics as the date on which Liquidated Damages commence).

Chapter 11

Compliance The contractor tendering against a specification is usually required to issue a statement along the lines of "our bid is in complete compliance with the specification" or to provide a list of all areas which have deviated from the specification.

Alternatives The consultant who prepared the tender documents will have been paid quite a significant fee to produce a cost effective design and specification. But they may not be up-to-date with current technology; or may decide not to investigate whether better options are available, so may allow the tenderer to offer an alternative design (provided that the tenderer submits a bid for the specified plant too).

Project Management This section identifies how the project will be managed and often contains 'hidden' costs associated with progress meetings, reports, QA documentation and Health & Safety issues. It might even stipulate what management software the contractor has to use.

Chapter 20

Validity The tender will normally be open for acceptance for a specified period of time or until a specified date, although the tenderer may revoke it at any time before (but not after) acceptance.

Terms of Payment The contract will set out when payments are to be made by the purchaser to the contractor, how much each payment will be as a percentage of the contract price, and what the contractor has to achieve in the way of milestones in order to be paid.

Chapter 18

If the tender is submitted on behalf of a company then it must be signed by an authorised signatory of the company – usually a Director or Company Secretary.

The Acceptance

In legal parlance, a tender is an 'offer' and not an 'invitation to treat' (no, this has nothing to do with buying drinks, 'treat' here means to bargain over the price). This means that acceptance of the tender by the purchaser concludes the contract and is legally binding on the tenderer. The tender may be conditional or unconditional but acceptance must be:

- complete and unconditional and in the manner and terms of the offer – any suggested variation constitutes a counter offer;
- made within the validity period of the tender;
- made whilst the tender has not been revoked;
- accepted only by the addressee or a previously nominated agent;
- communicated in writing.

Note that acceptance of the tender by the purchaser concludes the contract and cannot be revoked. Because the drawing up of contracts often takes a considerable time, the purchaser will sometimes issue a 'letter of intent' to allow the contractor to start work before the final contract is signed. This will normally be legally binding and will conclude the contract.

The rules that govern how the contract will be executed are set out in the Conditions of Contract.

Summary

- **You hope there's someone in your company who knows all this**
- **There had better be!**
- **It should be you.**

11

CONDITIONS OF CONTRACT

What's a Condition?

A 'condition' is a term in a contract that effectively sets out a promise which the contractor or purchaser must fulfil. If the contractor fails to do what was promised, then the purchaser may refuse to pay; equally if the purchaser fails to provide something which he or she promises to provide (for example, site clearance) then the contractor may refuse to complete previously agreed obligations.

The Conditions of Contract are supposed to be set down so that each party to the contract understands what their obligations are and that these can be formally agreed and recorded. In particular they define:

- the 'normal performance' required from each party (that's the work the contractor must do, the price the purchaser will pay, and when and how these may be varied within the framework of the contract without recourse to re-negotiation);
- how the risks (design, commercial, delivery, etc.) will be apportioned between the parties;
- the rules and procedures for conducting the contract and dealing with the problems and disputes which may arise; and
- the terms of payment.

Chapter 18

The conditions of contract are, therefore, fundamental to the execution of the contract.

Model Forms

Chapter 23

When engineering contracting first began, the purchaser appointed 'the Engineer' to manage the contract and to write bespoke conditions for the contract. Later, as more contracts were placed and consulting engineering firms became established, it became convenient for each firm to have its own standard conditions. These were, invariably, weighted in favour of the purchaser, and contractors began to write their own conditions which were, of course, weighted in favour of the contractor. As the contracting industry grew and projects became more complex, problems of misunderstanding, misinterpretation (that's deliberate misunderstanding) and, consequently, conflict between parties developed. Conditions of contract were expanded to cover these areas with the result that they became very lengthy and complicated: one firm's conditions might be quite different from another's. In order to provide a consistent approach the Institution of Civil Engineers produced a 'model form' of conditions of contract which could be used in all civil engineering contracts.

Other Institutions felt, with some justification, that the ICE Conditions of Contract were inappropriate to their members. After all, conditions that are suitable for constructing a road are likely to be quite inappropriate for the supply of jet engines for an airliner. The result is that standard conditions of contract have now proliferated, with many different model forms in common use, including:

- Institution of Civil Engineers (*ICE Conditions of Contract*, 7th Edition and *Design and Construct*, 2nd Edition)
- Institutions of Electrical and Mechanical Engineers and the Association of Consulting Engineers (IEE/IMechE)
- Institution of Chemical Engineers Conditions of Contract for Process Plant (IChemE)
- FIDIC (International Federation of Consulting Engineers) Conditions of Contract for Civil Engineering Construction
- Joint Contracts Tribunal (Building Contracts Conditions aka RIBA Conditions).

The situation is further complicated by the fact that there are different versions of the conditions for different types of contract so, for example, there are:

- IChemE Red Book for lump sum contracts
- IChemE Green Book for reimbursable contracts
- ICE Engineering Contract A: Conventional Contract with Activity Schedule
- ICE Engineering Contract B: Conventional Contract with Bill of Quantities

- ICE Engineering Contract C: Target Contract with Activity Schedule
- ICE Engineering Contract D: Target Contract with Bill of Quantities.

One of the reasons for this proliferation of conditions of contract is the wide variety of projects. The ICE Conditions of Contract, for example, are quite inappropriate when applied to mechanical and electrical plant. The ICE Conditions concentrate on tenders submitted against bills of quantities and remeasurement during construction, which gives quantity surveyors on both sides ample opportunity to submit claims and counterclaims. It's fairly obvious that working to conditions like this is confrontational.

As a further complication it's not unusual to find, in tender documents, amendments and/or supplements to specific clauses in the standard conditions of contract, especially if the documents have been drawn up by consultants who always consider that they are better qualified to write conditions than are the Institutions' committees.

Having spent most of my life in process plant contracting, I had had little contact with civil engineering. When I first came across quantity surveyors I asked a colleague what they actually did. "A quantity surveyor," he told me, "is the guy who goes round after the battle and bayonets the wounded".

"I have never seen an item covering a cubic yard of experience!" remarked a contractor complaining about this subject at a conference in 1971. Things have not changed significantly since.

Bills of quantities are appropriate in traditional civil engineering construction where, for example, large concrete structures are being built and where long underground pipelines are being laid and where the contractor is generally not responsible for the design. However, they don't work where a process plant is being constructed using steel pressure vessels. In this type of project what is most important is the performance of the process plant in meeting the required product quality. This is very much related to the process engineering skills of the contractor. The IChemE conditions attempt to address the problem by concentrating on process performance and by attempting to be conciliatory rather than confrontational.

Subcontracts

Few, if any, contractors have all the necessary skills in-house to execute modern construction contracts, which require civil, mechanical, electrical and probably process engineering capabilities. They may also require specialist skills such as orbital welding of stainless steel or the supply of specific items of process plant such as pharmaceutical stills. This means that the 'Main Contractor' will have to employ specialist subcontractors to provide these services. In fact many of the large main contractors employ no direct labour themselves but act as 'Management Contractors', relying totally on subcontractors for all design and site labour. This means that the conditions of contract between the main contractor and subcontractor are of great importance. It is common practice for the main contractor to try to impose on the subcontractor the same conditions of contract as apply to a contract with the purchaser, particularly in respect of liquidated damages. This 'back-to-back' arrangement is like a bookmaker laying off bets. The main contractor argues that if a subcontractor is solely responsible for a delay, the main contractor is still liable for the full liquidated damages, although it could be argued that mismanagement has resulted in the delay. So in practice the main contractor tries to pass responsibility and risk down to subcontractors, while still remaining ultimately liable for the completion of the contract.

> Passing risk to subcontractors means that a painting subcontractor with a contract valued at, say £10,000 could be responsible for delaying a £100,000,000 oil refinery and be faced with paying liquidated damages of up to, perhaps, 5% of the main contract price or £5,000,000. This is clearly unfair and quite ridiculous.

To avoid this sort of dispute and to ensure that each subcontractor carries an appropriate part of the risk, most main contractors have their own conditions of contract applicable to subcontracts. The IChemE has a specific set of conditions (the Yellow Book) for subcontracts which are based on the Red and Green books.

Damages

The conditions of contract will usually set out the guarantees which the contractor is required to meet. If a contractor fails to complete a contract on time or if the plant fails to meet the required performance, then the purchaser may suffer a loss and the contractor would be liable to pay damages in compensation for that loss.

The damages may be 'at large', that is they will be a direct reflection of the amount of money that the purchaser has lost. Suppose a contractor builds a factory and, because the foundations were faulty, a wall collapses and has to be rebuilt. This would constitute a warranty claim and the contractor would be liable for the cost of re-building. Now suppose that the wall collapsed onto an expensive piece of machinery. The purchaser has now suffered a 'consequential loss' as result of the contractor's mistake. The contractor could be held liable for the cost of repairing the machine unless the contract made it clear that they would not be held so liable.

As another example: suppose that a factory was due to be completed in time to produce toys for the Christmas market and – through the contractor's fault – the factory was not completed until January, then the purchaser can justifiably claim consequential loss. He or she may be able to estimate what the sales would have been and, therefore, quantify how much was lost because of the contractor's failure. The purchaser could sue the contractor for this sum but would need to be able to justify the sum claimed. These problems are never easy to resolve.

In plant contracting the situation is even more difficult. Suppose that a contractor guarantees that the power consumption for a particular item of plant will be 10,000kW but, when the contract is completed the performance test shows that it is actually consuming 11,000kW. Here the purchaser will have to spend around £200,000 extra per year on running the plant (assuming a power cost of 5p/kWh). This is a clearly identified

In 2005 Tesco began a project to build a new supermarket over a railway cutting in Gerrards Cross involving the erection of a tunnel of precast concrete segments over the twin track London–Birmingham rail line and backfilling to original ground level. The work was being done under a 'Design and Build' contract by Jackson Civil Engineering with consultant White Young Green and precast arch supplier the Reinforced Earth Company. The tunnel partially collapsed during construction, blocking the railway line and Chiltern Railways services were disrupted for several months.

The initial loss to Tesco was the cost of clearing the railway line and reinstating the collapsed tunnel section. However, there was a series of consequential losses:

- Tesco's planned opening date for the store was delayed resulting in loss of projected income
- Chiltern Railways were unable to run trains because the track (owned by Network Rail) was unavailable and would claim lost revenue and additional costs of bus replacement from Network Rail
- Network Rail would, in turn, claim against Tesco
- Tesco would claim against the contractor, Jackson Civil Engineering.

We await the outcome with bated breath!

In January 2005 P&O's £106m cruise liner Aurora, full of passengers who had paid up to £40,000 for a world cruise ticket, was marooned in the Solent for nine days because its propulsion system failed the performance test. It was specified to achieve a speed of 24 knots but achieved no more than 10. P&O had to pay out several million pounds in compensation, for which they sued the German shipbuilders who, in turn, sued the engine subcontractor.

loss for which the purchaser might justifiably claim damages from the contractor. If, as a result of the additional power costs, the product which the plant is producing is too expensive to sell or the profit margin is reduced then, again, the purchaser has suffered consequential loss and could claim damages from the contractor which could run into millions of pounds.

Assessing, justifying and claiming such damages at large is a lengthy and expensive legal process and the concept of 'liquidated damages' was introduced to avoid this. It is a sum (often a percentage of the contract price per week for delays or a formula for calculating financial penalties for shortfalls in guaranteed figures such as product quality or chemical or power consumption) which is agreed in advance by the parties as being a reasonable assessment of what the purchaser's loss would be. Note that if the sum agreed is excessive then it is a 'penalty'. In law a penalty is a threat ('in terrorem' is the Latin term and it implies that the contractor is in terror) and threats are unenforceable in the courts.

As well as guarantees for performance, contract conditions will usually identify a 'defects liability period', that is a period of time - typically one to three years - during which the contractor will be liable for the replacement or repair of any part of the works which becomes defective. This may include items of machinery, such as pumps, which have been supplied by the contractor and which carry a normal manufacturer's warranty. If the period of this warranty does not cover the whole of the defects liability period then the contractor may be at risk.

> We bought some pumps too early in a contract which was then delayed by six months. By the time we started commissioning the plant the twelve month warranty on the pumps had expired. Two of them failed during commissioning but, because the warranty had expired we had no claim against the supplier and had to pay for new pumps. This also shows how important it is to get purchases delivered at the right time – neither late nor early.

The contractor's liability will also cover 'latent defects'; that is, faults in materials, workmanship or design which are not immediately apparent but which become apparent during the defects liability period. Suppose a pump that draws water from a complex concrete reservoir fails and is repaired under warranty. Suppose it fails again and it is subsequently demonstrated that the failure is due to a badly designed suction arrangement in a concrete tank. The design and build contractor will be liable not only for replacing the pump (probably a relatively small cost) but, potentially, for rebuilding the reservoir.

As construction projects become larger and environmental protection legislation and other factors increase the potential for consequential losses, it is increasingly common for contractors to be required to provide financial guarantees to cover the risks. This means that only large highly capitalised companies – those whom the banks consider to be 'safe' for a large loan – will survive as main contractors, and explains why there is more amalgamation in the construction industry leading to fewer larger players.

Disputes and Resolution

The climate of contracting has become much more confrontational over the last decade. There are two reasons for this. Firstly, contracting has become highly competitive to the extent that contractors are knowingly tendering prices below break-even in anticipation of making their profit by negotiating 'extras' during the contract. Secondly, following the lead from the USA, contracting is becoming much more litigious both in terms of disputes between purchaser and Main contractor, and between Main contractor and Subcontractors.

> I was an expert witness in an action where a small electrical subcontractor from a country town claimed over £1m worth of extras against a very big main contractor. He was encouraged by his solicitor (who could see large fees for himself) in spite of the fact that the main contractor's solicitors were a large London firm. The electrical subcontractor's claims were grossly over-estimated and the claim was settled out of court for £100,000. The legal costs came to more than this and the electrical subcontractor went bust.

It is worth remembering that, conditions of contract and specifications notwithstanding, the contractor is still bound by the 1893 Sale of Goods Act and any goods supplied must be 'fit for purpose'. Also, conditions of contract, which are deemed unfair by a court, are not enforceable in law. Even so, disputes do occur and the conditions of contract normally set out the procedures to be followed. Litigation is expensive for both sides in a dispute and frequently takes months or even years. This is particularly onerous for small subcontractors, whose payments may be delayed until main contract claims have been settled, and who frequently go bust as a result. Most conditions of contract, therefore, try to resolve disputes without recourse to the courts.

> I was one of a number of expert witnesses in two cases about entire power stations. By the time we had all prepared our reports, haggled with our opposite numbers and produced some kind of agreed document, it was fairly clear how the judgement would go. At this stage it is sensible for the parties to settle out of court. Although the legal costs will already be high, they will increase dramatically once the team of QCs, solicitors and assistants start attending court for days on end.

Traditionally, in litigation, both parties appoint 'expert witnesses' to advise on technical matters and to present evidence. Although these experts are supposed to be independent, each of them will obviously present findings in a way which presents the client who is paying the bill in the best light. There has recently been a move to a 'single joint expert' who is appointed by the court and whose fees are paid half by each side in the dispute. Both sides agree to abide by the joint expert's findings.

In normal day-to-day operations, the Project Manager, who is usually nominated in the contract (or a delegated agent) is the arbiter of the conditions of contract. In some Conditions of Contract the Project Manager is called 'the Engineer' but this is generally recognised as adversarial. Work to be carried out under the contract is often required to be "to the satisfaction of the Project Manager". If there is a dispute between the contractor and the purchaser then the Project Manager will normally rule until such time as the dispute can be settled by a third party. Chapter 23

Under the Housing Grants, Construction and Regeneration Act 1996, any dispute under a contract within the UK which includes construction operations can be referred to an 'Adjudicator'. The adjudicator will ascertain the facts of the dispute and give a ruling within twenty eight days. That ruling will then bind the parties, unless reversed by arbitration or litigation. Under certain conditions of contract (e.g. IChemE) the role of the adjudicator is carried out by a mutually agreed *expert*, but the aim – of low cost settlement – is the same.

If adjudication fails, the next step is 'arbitration', where an independent, competent person (nominated under the contract) is called upon to resolve the conflict. This is a legal procedure involving solicitors and the discovery of evidence, so it is much more expensive and time consuming than adjudication. However, if arbitration fails, the only alternative is litigation. That is more expensive still, and beyond the means of most small contractors.

> "In England, Justice is open to all - like the Ritz Hotel." *Lord Justice Mathew (1830-1908)*

Most of the disputes that arise in contracts are the result of misunderstanding or misinterpretation of the Specification so it's important that engineers write clear and unequivocal Specifications.

Summary

- **More legal stuff, but of crucial importance to anyone involved in project engineering, whether as purchaser or contractor**
- **A good relationship between the Project Manager and the contract manager is the best way to stay out of trouble**
- **When major problems seem impossible to resolve, it is usually because contract conditions are not well drafted or are insufficiently clear.**

12

HOW THINGS CAN GO WRONG – 2

This example is of a gas-fired power station which was built on a large industrial site in the East Midlands. An operating company was formed and became the purchaser. Its shareholders included the owner of the industrial site, the main contractor who was to build the plant and an electrical power generating company who would operate it when it came on line. On the face of it, the project therefore resembled a DBFO project, with the minor difference that the operating company would own the station for ever.

Chapter 17

I was engaged as an expert witness on the water purification plant, by the solicitors acting for the operating company. They had been sued by the main contractor to recover the money which the bank had paid out under a performance guarantee.

Chapter 18

As I studied the customary van-load of papers, it became clear that the entire contract had been shambolic, not just the water treatment plant. There had been no Critical Path Analysis, in fact no proper plan of any kind. There was a fundamental fault in engineering the control of the steam supply to the deaerator. These mistakes were so silly that no useful lessons can be drawn from them. The water treatment plant, on the other hand, was a splendid model of How Not To, in various respects.

Chapter 20

Chapter 15

The main construction contract to build the station was to be a negotiated one, without competitive tendering. A specialist consultant was engaged to prepare a specification, and the main contractor began pricing the contract. While the main contractor was a major shareholder in the client company, his relationship with the consultant was the same as in normal competitive tender projects. With hindsight, it looks as if this arrangement gave them the worst of both worlds – a contractor who was not in competition with others, but who nevertheless would try to maximise his profits by producing at the lowest possible cost to himself. That is precisely the situation which a well-run DBFO contract should avoid.

The main contractor appointed one of his engineers (Mr X) to take charge of pricing all the equipment connected with steam: water treatment plant, boilers and turbines. The boiler and turbine makers told him how much steam they would need, and what purified water quality was required.

The feed water for the water treatment plant was from public supply, and Mr X obtained a water analysis from the water company. The analysis sheet came with a handwritten note scribbled on it by the water works' chief chemist, to warn him that this was an average analysis, and would vary throughout the year.

On the basis of these facts, Mr X wrote an enquiry specification for the water treatment plant sub-contract. In it he specified the process flow sheet which was to be used. This specification contained Mistake 1 in asking for the water treatment plant to be designed to treat the water shown in the analysis, without saying that this was an average.

The public water supply came from a reservoir fed by several small streams which meant its quality would vary with the seasons, unlike waters taken from an underground source which tend to remain the same throughout the year. The streams which fed it drained heavily populated farmland, so that the water coming into the reservoir contained treated sewage, farm run-off, etc. It contained a fairly high concentration of dissolved minerals and (again unlike water from underground sources) a lot of dissolved organic matter. The water works treated it to make it suitable for drinking water, but it contained organic impurities. These are harmless to health, but not to boilers.

As is normal, several water treatment plant subcontractors visited the main contractor for pre-tender meetings. One of these was my old company and its chief process engineer explained that the specified process flow sheet was not up to the job: it would not deal effectively with the organic content of the water. Here Mr X made Mistake 2 by responding with "p*** off and quote to the specification!". So he did just that: he designed and offered a plant which would meet the enquiry specification, but he knew it would not produce the water purity which was needed. So, presumably did his competitors.

Mr X selected one of the offers which he received (not my old company's), and it was incorporated, with all the plant details including unit sizes, into the contractor's proposal for the complete job. The consultant was satisfied with the proposal, and the contract was signed on the basis of this price and specification.

The main contractor now had a contract, and had to purchase the equipment, so Mr X issued a fresh set of enquiries, including one for the water treatment plant.

This was a repeat (mistakes and all) of the first one. Now that the main contractor actually had an order to place, all the companies tendering for the water treatment plant took a lot more trouble with their offers, and aimed to be more competitive than during the first round of bidding. It turned out that yet another company was offering a plant which was much smaller than the one which had been written into the main contract. It was, of course, also much cheaper. Mr X now made Mistake 3, which was to accept the lower priced offer, and order it rather than the plant which had been described in detail in the contract. I never did find out why the lawyers did not consider this a clear breach of contract.

Fabrication was almost complete when it was discovered that the water analysis had indeed changed. The mineral content of the water had risen, and this would put more load on the water treatment plant. The bigger plant described in the main contract would have coped with it, but the cut-price job about to be installed was obviously too small. Larger pressure vessels were hastily ordered to increase its capacity, but there was an inevitable delay of some months.

> To some extent this was bad luck. The banks of the water company's reservoir developed a growth of toxic algae – three sheep and a dog had died from immersion in the water. The water company poured chemicals into the reservoir to deal with the algae, increasing the mineral content of the water. That, in turn, put extra load on the deionisation plant. The plant which had been detailed out in the main contract could have coped with it, but not the cut-down version which was actually ordered.

When the enlarged plant was finally started, it had the necessary capacity, but it failed on treated water quality. The boilers could accept it, but it contained volatile impurities which made the steam off-spec. The turbine manufacturer said that its use would void his guarantee. There was a further delay while mobile emergency plant was hired to polish the product.

All this had cost money, but the biggest cost was a delay of at least six months in starting the whole station – the loss of revenue ran into millions. There had indeed been other problems, but the main delay was probably that caused by the water treatment plant problems. The purchaser decided to activate the performance guarantee, the contractor brought a lawsuit to recover it, so here we were.

Chapter 18

> Bearing in mind that the contractor was a major shareholder and must have had his Director(s) on the Operating Company's Board, the scene in the Operating Company's board room when this decision was taken must have been most interesting.

The subcontractor who had built the inadequate water treatment plant was of course not to blame – not in law, at least. If the water was more heavily mineralised than the analysis in the specification, that wasn't the subcontractor's fault. It had been designed according to the process flow sheet which had been laid down in the specification: if that didn't produce the required quality of product, that wasn't the subcontractor's fault either.

The case never came to court. The two parties settled it on terms which were never published (which is quite normal). All I know for certain is that the main contractor went out of business a few days later.

Summary

- **DBFO must be organised in such a way that everyone is working for the operating company, not just a part of it**
- **Contractors are likely to have more experience relating to a project than the clients. That's particularly the case with specialised equipment**
- **If there are two offers for the same spec, of which one is much bigger than the other, one of the two must be wrong. When designing plant in a competitive situation, excessive caution is rare, but under-design is not. The smaller design must therefore be viewed with suspicion.**

One other point is so obvious that one can't call it a 'lesson'. When I had learnt what gross mistakes were made in ordering the water treatment plant, I thought I would find out something about Mr X himself. I dug out his CV and discovered that he was an Electrical Engineer, specialising in switchgear. He had not studied chemistry at A level and most probably not even at GCSE. When purchasing a chemical process plant, you would think, Mr X might have taken a bit of advice. If he didn't trust my ex-colleague's warning, he could have engaged a specialist consultant for a couple of thousand pounds and saved his employers millions.

I often find myself quoting the German poet Friedrich von Schiller: "Gegen die Dummheit kämpfen die Götter selbst vergebens" – "against stupidity, the Gods themselves fight in vain".

Figure 5 *Gegen die Dummheit kämpfen die Götter selbst vergebens*

13

COST CENTRES

What's a Cost Centre?

A Cost Centre is an accounting tool which allows us to treat staff costs which would otherwise be regarded as part of the company's overheads, as direct costs.

Chapter 7

When a contractor makes up a price for an offer, the biggest item after the estimated BOC (bought-out-costs) is the contribution, most of which is needed to cover the company's overheads. (Just to remind you – overheads are the costs which can't be attributed to a particular contract.) If we could attribute more of the costs to contracts, therefore, the direct costs would increase and the overheads fall, so that the percentage of contribution which has to be added to calculate the selling price would be smaller. That in turn would allow us to get a more accurate estimate for the price at which the contract should be offered.

Many of a company's full-time employees do work which could indeed be attributed to contracts, but to do that it needs a suitable system. This is done by creating Cost Centres.

How does it work?

A Cost Centre has to have two characteristics: it must be a part of the company whose work and costs can be separated out from the rest of the company, and its output for the company must be measurable.

For example, my company had a highly skilled erection staff – people who would go on site after we had delivered the components of the plant – vessels, pumps, pipes, etc. Their job was to assemble the plant to the point where the commissioning staff could take over and get it operating. I mentioned before that this is a skilled job but that, in the nature of our work, we couldn't guarantee that we would have work for them throughout the year. When they didn't, we would hire them out to other companies. It was therefore most important for us to know what their work was actually costing.

The biggest cost element here is the salary cost of all a company's staff – not only the operatives who actually do the work but also those who aren't in the front line, like the department's manager, and its clerk. 'Salary cost' includes national insurance, pension and all other such associated costs. Then costs like transport, telephones and IT – all quite high for this type of work – must be added. (A sophisticated scheme might also add rent for their office space, electricity, and so on.) By adding all these together, we get the total sum which it costs the company to run the erection department for the year.

All this 'modern management' stuff is relatively new. In the 1960s I worked for a process plant contracting company whose accounts system had no cost centres, so none of the work done internally could be booked to contracts. As a result, the company's standard price make-up formula was BOC + 50%!

Man-hours

The department's output is measured in terms of man-hours. We know how many operatives (the guys who actually do the work) we have, but how many hours of attributable (i.e. money-earning) output can we expect from them?

Let's assume that the operatives work 40 hours a week. If we allow 4 weeks for holidays and two weeks for national holidays, etc., that means that in 46 weeks, they have 1840 working hours per year. The real number to take, however, is much lower because there are always a lot of hours which can't be attributed – for example, time spent on remedial work for an old contract whose books are closed, so it can no longer be booked to the job. As a practical figure 1500 hours/year is more realistic.

We can, therefore, calculate that the cost per man-hour is:

$$\frac{\text{Total Department Cost}}{\text{Number of Operatives} \times 1500}$$

If the estimating department estimates the man-hours it will take for erection of a project, we can calculate an estimated erection price to go into the price make-up as a separate estimated item, rather than as an unknown amount which is buried somewhere in the overheads.

Project management, draughting, purchasing (or procurement) and commissioning can all be treated just the same, and the output of those cost centres, too, would be in man-hours. Engineering is a bit more complicated because the department is usually bigger and multidisciplinary, and there is considerable variation in salaries and overhead costs across those disciplines. For our first few years we considered all design work as a single cost centre, but when it became clear how big the differences were, we treated each discipline separately with its respective cost per man-hour.

Obviously the system depends on timesheets for anyone whose man-hours are being attributed. There is a range of levels of sophistication – our Dutch partners (the ones who were caught out by the painter who only sent invoices annually) went overboard and installed a system in which everyone including the MD filled in timesheets. I thought this was over the top – as the numbers for calculating costs are based on estimates, there's no point in aiming at great accuracy. It means more form-filling and costs more than it's worth.

The output of a Cost Centre isn't necessarily measured in terms of man-hours. 'Purchasing', for example, can also be evaluated in terms of the value of materials and services to be purchased. The total value of purchases in the year is divided by the total cost of the Purchasing Department. The resulting number might be of the order of £1 Per £1000 purchased.

Eventually the old company which had used BOC + 50% as its basis for estimating prices, went down the drain. We then founded a company to do the same kind of work, but we installed a system which included cost centres. That made our price make-up formula BOC + Cost Centres + 25%. With a mark-up which was so much smaller than that in the previous company we could gauge the correct selling price much more accurately.

Cost centres also provide a way of monitoring efficiency. When the man-hour cost of our drawing office increased above that of our local draughting agency, we had to consider whether it was actually worth keeping our own CAD operators or simply outsource the service. (We decided to keep our own staff but managed to reduce the department's costs.)

Chapter 9

Cost centres have another use, which is perhaps even more important. When estimating the man-hours for a job, one can also predict when they are likely to be carried out. So, for example, engineering a job which is expected to take a year to complete might be estimated to use 500 hours in the first month 300 in the second and 100 hours in each of the next seven months. The Management Accounts will record the actual man-hours booked each month, side by side with the original plan. If they vary significantly from the plan, it shows that something is going wrong. If the figure of 'hours used' is too high, there seems to be trouble somewhere: if it is too low, it means there has been some delay. Either way, it signals that something probably needs to be done. That's why it is important for the Management Accounts to be prepared quickly - if they come out three months in arrears, it is probably too late to do much about the problems which they might show up.

If you are a staff engineer working on a number of projects at the same time it is often difficult to keep track of time spent on each (or none!), and many timesheets are works of fiction. One research company I worked for early in my career had a cost code for "reading and thinking unconnected with specific projects".

The accounts also provide historical data of man-hours spent on contracts against those estimated, which is useful for estimating man-hours for future contracts.

Summary

- **Cost centres are a way of treating staff costs as direct costs**
- **They provide a means of calculating a cost per man-hour for each department**
- **They provide a way of achieving better estimates of contract costs for pricing**
- **They also provide the basis for monitoring progress, managing cash flow, and estimating future contracts.**

14

PRICING CONTRACTS

The price of the contract

When I first started work in the proposals department of a contracting company an older, wiser and very much more cynical engineer told me that a contract price was "a blind guess carried out to seven significant figures". I thought he was joking but, looking back from twenty years on, I can see that there was more than a grain of truth in it.

The fact of the matter is that cost, price and value all mean rather different things although they are all expressed in the same number: in our case, the contract price. Contracting is a competitive business and, all other things being equal, purchasers generally place contracts with the lowest bidder. So, just as in the supermarket or the petrol station, the lowest price gets the order. Too high a price means that the company doesn't win any contracts and fails because it cannot cover its overheads, and too low a price means that the contribution is too low to cover the overheads. Either way, the company will fail.

Competition

Contracting is highly competitive because it takes relatively little capital to start trading. That's how four partners and I started a company in 1971. At about Chapter 6
the same time various competitors also emerged from nowhere. Somehow we survived the resulting fierce competition and, within only a few years our clients thought of us as well established, and a bit stuffy.

With such fierce competition, profitability (i.e. profit as a percentage of turnover) will always stay low but, provided that the potential return on capital is high, this is not a business problem. On the other hand, low profitability means that the margin for error is small, and contracts can easily swing into loss. In many real-life cases it only takes one or two bad contracts to break a company – even a big one.

No two contracts are the same. Even if the technical content of a contract is the same as that of a previous one, there will be differences like varying site conditions; labour conditions; costs may have shifted in the interval; the time of year and the weather play a part, and so on. Compare this to manufacturing, which takes place in a more controlled environment. That makes it easier to give an accurate estimate of the cost of producing the product.

Making up the price

Chapter 13

When a contractor receives an enquiry from a purchaser there is a limited, and usually short, period in which to submit a price. During that time (typically six to twelve weeks) the contractor's Proposal Manager has to get a preliminary design prepared, estimate the materials and subcontract costs (usually called the 'bought-out-costs') and the direct costs from their own cost centres – engineering, procurement, project management and so on. To this must be added any other direct costs and finally the contribution calculated in the year's business plan. This will all be set out in a document called a Price Make-Up Sheet or something similar, like the one that we looked at earlier. Now is the time to have another look at it and see what the numbers mean. The Price Make-Up Sheet is a very important document because it not only shows how the tender price was arrived at but, if the company wins the contract, it will be the basis of the contract manager's budget and cash flow forecasts.

Chapter 9

The form I have set out (see the next page) is the one we used earlier. It's a simplified version of a real Price Make-Up Sheet and, in any case, all companies have their own particular way of setting things out, but it will serve to illustrate the important points which they must all include. It's for a typical mechanical and electrical contract of the type that my company used to carry out. It would be a good deal more complicated for a civil/mechanical/electrical turnkey contract. The Price Make-Up Sheet is a summary and will be supported by detailed estimating sheets and quotations from material suppliers and sub-contractors.

Notes:

1. The materials cost is the sum of all the equipment and materials that will be purchased for the contracts – concrete, shuttering, steelwork, pumps, pipes, specialist machinery and so on.

CONTRACT PRICE MAKE-UP SHEET

			£	£	**£**	
Mate rials	mechanical			440000		
	electrical			250000		
	control &			100000		
	instrumentation					
	deliveries			10000		
	Sub Total				**800,000**	Note 1
Installation	mechanical sub			50000		
	contract					
	electrical			30000		
	subcontract					
	Sub Total				**80,000**	Note 2
Engineering	process	300 hrs	@ 35.00/h	10500		
	mechanical	650 hrs	@ 30.00/h	19500		
	electrical	450 hrs	@ 30.00/h	13500		
	controls	400 hrs	@ 35.00/h	14000		
	drawing	500 hrs	@ 25.00/h	12500		
	commissioning	250 hrs	@ 40.00/h	1000		
	Sub Total				**80,000**	Note 3
Management	manager	2000	@ 40.00/h	80000		
		hrs				
	procurement	500 hrs	@ 30.00/h	15000		
	QA	300 hrs	@ 30.00/h	9000		
	safety	400 hrs	@ 40.00/h	16000		
	Sub Total				**120,000**	Note 4
Site	offices	50	@ 200.00/week			
		weeks				
	craneage	200	@ 200.00/day			
		days				
	support staff	8000	@ 15.00/h			
		hrs				
	telephone					
	stationery/printing					
	transport					
	Sub total				**200000**	Note 5
Finance/	interest	2.0% of Contract Price		37373		Note 6
Miscellaneous	agent's fees	1.0% of Contract Price		18686		Note 7
	fixed price	2.0% of Contract Price		37372		Note 8
	licence fees	0.5% of Contract Price		9343		Note 9
	insurances	1.0% of Contract Price		18686		Note 10
	Sub Total				**121,460**	
Total direct costs					**1,401,460**	Note 11
Contribution		**25% of Contract Price**			**467,153**	Note 12
Contingency					**0**	Note 13
CONTRACT PRICE					**1,868,613**	Note 14

2. Sub-contracts are packages of work that will be carried out by other companies on site as opposed to direct labour employed by the contractor. Typically this might include piling, scaffolding, equipment installation, electrical cabling, painting and similar activities. The sum of materials and subcontracts (1 + 2) is usually called the 'bought out cost' (BOC) and is usually the biggest single cost item.

3. Engineering is estimated on the basis of experience; that is, the Proposal Manager will talk to the various discipline engineers, explain what's involved in the contract and ask them to estimate how many man-hours of design they will need. The cost per man-hour is arrived at by considering the engineering department as a cost centre.

Chapter 13

4. Contract management and other direct costs are estimated in much the same way.
5. Site costs will vary from contract to contract. Here good design can save a lot of money. Prefabrication off site might mean the difference between having an expensive tower crane on site for months and having a mobile crane on site for days. It's the small things that are often overlooked that can increase costs – site safety clothing, computers for the site office, photocopying vast amounts of paperwork for QA records and cost analysis. Large contractors will own earth moving equipment, vans, site cabins, computers, and so on and simply rent them to the contract manager for the contract period. Smaller companies will have to buy or hire this sort of stuff.
6. At the tender stage, the Proposal Manager will prepare a cash flow forecast and an 'S' curve for the contract so as to be able to estimate how much money will have to be borrowed and how much interest is attributable to the contract.

Chapter 21

7. In overseas contracting it is quite usual to have an agent (an individual or a company) who knows the local situation and has good contacts within the purchaser's company so their help may be invaluable in winning the contract.

> Bribery is clearly illegal but, in some countries, it is a way of life and business is very difficult to do without it. Some of the contracts we tendered in Africa back in the 1970s contained high levels of 'Agents Fees'. Nobody knew what the Agent did with the money…

8. Most contracts are 'fixed price' contracts which means that the BOC, estimated on today's price, may increase during the contract period. Even in an eighteen month contract period there is likely to be a small increase in materials costs and quite probably engineering costs, so either the suppliers have to quote on a fixed price basis or a percentage has to be added to allow for inflation.

> Don't confuse a fixed price with price fixing. What people generally understand by 'Price fixing' is an illegal practice, when contractors get together secretly and rig their prices high: the one who gets the contract then pays off the others. That is legal only if it's done openly and with the client's consent, which is rare in the Uk.

9. In some specialist sectors, contractors might be using technology that they have obtained under a licence agreement, and they have to pay a licence fee or royalty to the owner of the technology.
10. Contractors normally carry a 'contractor's All Risk' insurance that covers them for damage or injury to staff, subcontractors and third parties as well as for mistakes in the design and consequential losses. Sometimes they need to take up special insurance. For example, overseas contracts may involve insuring equipment in transit by sea. The cost of these special insurances can be quite significant.
11. Adding all these items together gives the total direct costs of the contract.
12. The contribution is, of course, a key number. It may be the straightforward number calculated in the year's business plan or it may be higher if the contractor is confident of winning the contract or lower if he or she wants to be sure of getting it.
13. The price may include a contingency to reflect a particular type of risk or liquidated damages in the contract or to provide a 'negotiating margin' for the salesman to give as a discount without affecting the overall return on the contract.
14. And there it is: the Contract Price – well almost.

Note that profit isn't mentioned anywhere. A single contract makes no profit, so it's senseless to speak of profit at this stage.

Finalising the price

The Price Make-Up Sheet is not the final step. There is the 'Price Settlement Meeting'.

All the things I've talked about so far are costs and are quantifiable. Now we have to look at a set of factors that influence the price but are not quantifiable. These are discussed at the Price Settlement Meeting (other companies will have other names for it) when the people directly involved in the tender – the sales engineer, proposals engineer, contract manager, engineering manager and at least one director – will discuss the factors and make a final decision on the price to be submitted. So what are these unquantifiable factors?

The first is competition. The sales department should act like an army's intelligence corps and try to find out as much as possible about the background to the project. In standard commodities like cars or tins of baked beans, you look at the competitors' price and work to that. In the motoring magazines you can read that such and such a car is aimed at the 'Ford Focus' market – that is the lower-priced middling sized family five-door car. Other manufacturers know the cost of a Focus and design and price their cars to compete with that. In competitive tendering this is (theoretically) not the case, though there are devious means of finding out what the competitors' prices are.

In the 1990s the UK economy was in recession and there was little construction work going on except in water works, which had to upgrade to meet new legislation. This sector became very competitive and one contractor in particular won most of the work by offering very low prices. Soon the consultants who prepared the tender documents found that they were unable to get other contractors to bid for contracts so they had to start placing contracts with other contractors who weren't necessarily the lowest priced. Some contractors did rather well out of this…

Does the purchaser have a budget limitation? If so there is no point in tendering a price that is higher. Does the purchaser have a preference for a particular technology that is available to only one of the bidders? Which other contractors are tendering and do they have a particular reason for submitting a low price – are they short of work, for example? Some contractors have a reputation for bidding low prices and then stinging the purchaser with expensive extras.

Secondly, there may be a particular reason why a contractor might want to win a particular contract. Perhaps it's a 'prestige' project that will enhance the contractor's reputation, in which case he or she might want to offer a particularly attractive price.

Thirdly, it's important to be aware of any particularly onerous conditions of contract – punitive liquidated damages for example, or a particularly high risk such as unknown ground conditions or a Site of Special Scientific Interest – that will require special contingencies to be added. Contracting is a risk business, but extra money on a contract serves as a kind of insurance premium.

Back in the 1980s there was a sudden growth in the semiconductor industry in Scotland's 'Silicon Glen'. Each new factory needed a plant to produce ultrapure water. The technology was poorly understood and shrouded in mystery. It was important for contractors to have demonstrable experience in the field before they could win a contract. The five or six specialist contractors each 'bought' a contract by tendering a price with little or no contribution in the hope that, having built one plant, the experience gained would stand them in good stead for the next contract, which they would price normally. By the time each contractor had done this there were no more factories to be built so none of them made any money out of what should have been a premium price market.

Weighing up all these factors will usually lead to an adjustment to the calculated price – typically the sales department will be arguing to reduce the price whilst the operations department, who have to execute the contract, will argue for a higher price. And, finally, there it is: a blind guess carried out to seven significant figures.

Mistakes are made in pricing. I remember one student who didn't believe this. "Surely these people are all qualified engineers," he said. Well, engineers make mistakes just like everyone else. Interestingly, errors in pricing always seem to make the price too low, never too high. I once priced up an overseas project late one evening and, instead of adding 10% for the agent's fee, I deducted 10%. We won the contract by about 5%. It was only after we'd won it that the mistake came to light.

Tender costs

Preparing tenders is a costly process. Although the tender stage design is not fully detailed, it will take a full team of discipline engineers – process, mechanical, electrical and civil – as well as planners, estimators, architects and draughtsmen. A typical £2m tender might cost £20,000 to prepare – that's 1% of the 'contract price, and that cost is part of the contractor's overheads. We used to expect to win one tender in four, which I think is fairly typical, and we got no reward for the work which we put into the other three unsuccessful tenders.

In Holland it's not uncommon for contractors to club together and agree on a sum which covers the cost of all of them tendering. Each offer includes this sum, which is then shared between them from the winner's contract price. If this is done openly, it is quite legal, but I have never heard of it being done in Britain. The Dutch are a very sensible nation.

Summary

- **Many items go into working out a contract price**
- **We try to minimise uncertainty with cost centres and so on, but much remains a best guess**
- **With thin profit margins, small errors make a big difference to profitability.**

15

COMPETITIVE TENDERING

Tendering

There is a basic problem in placing a contract and of settling the terms on which it is to be performed. Naturally enough, the contractor wants to get the most money for the least expenditure, and the client wants to get the best product, also for the least expenditure. Theoretically the two aims can both be met, but we haven't actually got a very good route for getting there. The tendering process is normally a competitive one, aimed at securing the lowest price for the execution of a clearly defined scope of works (the word tender means an offer).

The purchaser (or their consultant) prepares a document (an 'invitation to tender' or 'Tender Document') which includes a specification for the works to be executed, together with conditions of contract and technical information, and sends this to prospective contractors. The contractors each prepare documents ('proposals') which set out how they propose to achieve the requirements of the specification, and include tenders (offers) for carrying out the work. The words 'tender' and 'proposal' are often confused but, in law, they are quite different. The purchaser reviews the tenders and selects that which represents the best value. With a detailed specification this is usually the lowest price. However, issues of reliability, etc. can arise. The law obliges a lot of Government contracts to be placed in this way, and there is a formal procedure by which the offers have to be in sealed envelopes to be submitted by a fixed 'Closing Date', when the envelopes are opened in an official ceremony. All this is supposed to ensure fair play and avoid corruption.

I have spent many years working in and running proposals departments, which is where a contractor's tender document is produced. The most important lesson I learnt about competitive tendering is that any contract which is let to the lowest bidder is let to the contractor who made the biggest error in a proposal. This is my first law of contracting. The second law states that, having won the contract, the lowest bidder will invariably employ the lowest bidding subcontractors in an attempt to reduce direct costs. The corollary is that every major project is being built by a contractor who doesn't have enough money to do it properly. One of the reasons for this is the way in which tenders have to be submitted within a relatively short tender period, which means that the designer and cost estimator have to get it right first time – there is no time available for a second try.

> Errors in proposals may be in the design, the cost estimate or in the scope of supply. I well remember winning a contract by a margin of about 10% from a competitor. About a week into the contract period our contract manager asked me, politely, where the costs estimate was for the very complex control and telemetry system that the Client had specified. I had to admit that I hadn't read that page of the specification. The control system, in compliance with the Client's specification, added about 20% to the contract price, so I excused myself by pointing out that if I'd got the scope of supply right, our price would have been higher than our competitors' and we wouldn't have won the contract. It's a bit of a moot point whether we were better off winning it or losing it.

At best, things can go well, but that takes reasonable trust and goodwill on both sides, and some spirit of achieving a common objective. It means that the personal relationship between the purchaser's Project Manager and the contractor's contract manager becomes all-important, which is not a thing we should have to rely on. At worst this way of organising a project is so adversarial that it satisfies no one – the contractor makes little profit or even a loss, and the client gets an unsatisfactory end result. The system suffers from a number of shortcomings in that the specification writer has to define unequivocally what is required, the proposal engineer writer has to design and cost the work accurately in the time available and define clearly what is being offered, and the purchaser has to have the ability to select what is really the best offer.

Chapter 11

Many companies who invite contractors' bids follow much the same pattern, though they are not legally obliged to do so. Some clients have lists of contractors and won't consider anyone not on the list. For some large international jobs, contractors have to present their credentials, and/or buy the contract documents for a sum which is large enough to discourage frivolous offers.

The procedure traditionally goes back to simple Civil Engineering projects, with detailed specifications and no complications. Where that is the case, the client looks at the offers; checks whether they comply with the specification;

Chapter 10

identifies the cheapest offer by a contractor who can be trusted to perform the work; and goes ahead and places the order. Simple.

Not so simple

Chapter 23

Most large contracts nowadays are more complex. When the project is first given the go-ahead, the client (or their consultant – and I shan't go on repeating this) may invite one or more potential contractors to discuss it. These pre-tender discussions help the client and contractor to understand one another, and what the project is all about. The client may well get some good ideas from the contractor before the specification is written.

The bit about opening sealed envelopes makes it all look absolutely fair, but the reality may be rather different. When the offers have been examined, the client will hold 'Post-Tender Meetings' to discuss it – possibly only with the successful contractor, to resolve any difficulties or uncertainties, or with several contractors who are in the running, to decide which is best. The client may even suggest to them to make some change to their offer and re-tender.

The contractor's representative at such meetings may be a contract manager, or a Proposals Engineer, or some such title. In a small company this may even be the Managing Director. The function performed at the meeting, however, is that of technical salesman. Engineers (who can be terrible snobs) may look down on 'salesmen', but this is a very skilled job. It not only means a good grasp of the technology, but also a talent for inspiring confidence in this skill. The salesman also needs to understand all the financial implications which the contract would have for both parties.

One of my unhappiest memories: a company near Birmingham issued an enquiry for a plant to remove nitrate from drinking water supply. It was to use a novel process on which I had done a lot of research. Thanks to that, I could put forward an alternative which would be so much cheaper and easier to operate – I thought we couldn't fail to get the contract. I hadn't reckoned with the post-tender meeting, at which they gave a locally-based competitor the details of my alternative and suggested he re-tender on that. Surprise! His offer was cheaper and he got the contract. Pretty dirty play, I reckon; it wasn't actually illegal, but very unprofessional.

Sometimes there is conflict within the client's camp: the technologists know which contractor they want to work with, even if they are not the cheapest. Maybe they have worked happily together before, or maybe the cheapest contractor looks unreliable, or maybe the technology on which the cheap offer is based is likely to be troublesome. The client's Purchasing Officer (or whatever the title of the job may be) will go for the cheapest. Maybe the engineers want a dearer offer to win because it has more spare capability and will therefore be less likely to fail. "What's wrong with the lowest offer?" they will be asked. "Well, er…" it may be quite difficult for the engineers to put their preference into numbers. "Has the contractor given us a guarantee?" "Well, yes". "So what's the argument about? We'll give them the contract".

A guarantee (which generally accompanies a contract) is of limited efficacy. When a project fails, the reasons are usually various and uncertain. That makes it impossible to pin responsibility on any one cause and on one of the two sides in the argument. As a result it is usually difficult to make a guarantee stick.

Of course, if the client's specification is wrong, the whole thing is doomed from the start, but that is not the contractor's concern. Once the contract is won, the only objective is to meet its terms as cheaply as possible, and there's nothing more the client can do about it. Whether the result actually satisfies the client is immaterial – unless there aremore projects on the way and the

We built a boiler feed water plant for a nuclear power station. The enquiry specification said it was to be fed with potable water from the water company via an existing cast-iron ring main which would be dedicated to the power station. That meant reversing the direction of flow in it. The terms of the contract obliged us to satisfy ourselves as to the quality of the feed water. We didn't think that was necessary, but when the plant started up it clogged solid – not just once, but again and again. The client refused to pay. A close look at the rubbish which clogged it showed it contained (among others) freshwater shrimps. The EU Directive for potable water doesn't allow shrimps in potable water, so we claimed we had been misled and won our case. What had happened? The cast-iron main had accumulated a lot of organisms on its walls. When the water company reversed the direction of flow they were all facing the wrong way and came off.

Chapter 24

A contract for a CEGB power station at Warrington presented a novel technical problem: I did some work on it, got it wrong, and our plant failed its acceptance test. It turned out to be the costliest mistake I ever made because the CEGB were about to place two more large orders, so our keen Sales Director was moved to offer a remedial plant free of charge. At a meeting I was told that the only available site for it was downwind of the cooling towers. "What does that mean?" I asked. "There'll be a constant drizzle of cooling water". "And what do you use for cooling?" I asked. "It's river Mersey water, untreated," they replied. I thought about this for a bit and said, "You mean: The quality of Mersey is not strained/It droppeth as the gentle rain from heaven".

Nobody laughed, and I still wonder whether they had no sense of humour, or just didn't know their Shakespeare.

Chapter 7

Chapter 12

contractor wants to be in a good position to get these other contracts. Even then contractors will only take action if it seems the shortcomings of the project are their own fault. So this way of placing orders can easily go wrong, especially if the client is not able to judge whether an offer is technically sound or not. That is, sadly a common state of affairs.

To repeat: the problem with this way of placing contracts is that contractor and client do not have a common objective. Sometimes, indeed, the proceedings become horribly adversarial. No sensible system would let contractors build projects which they know are unsound. No sensible system would encourage contractors to cut every corner they think they can get away with. (Civil Engineering, for example, is full of cases where it transpires that the contractor had increased takings by using a leaner concrete mix than that specified.) Hence the search for better ways of arranging things.

Negotiated contracts

Placing contracts 'by negotiation' is one alternative which similar in some respects. Instead of asking contractors to send in competitive quotations, the client discusses the project with potential contractors and selects the one who seems the best. Client and contractor then go through the project in detail, agreeing on the specification and pricing its components as they go, to build up a specification and price which are the basis of the order.

This method is favoured by the Japanese, for whom it seems to work rather well. The reason is not far to seek: in order to do this, the client must have the expertise to deal with all the detail involved. The Japanese employ more engineers than we can – without this resource the 'negotiation' would be pointless. This system should result in a better contract (for both parties) than our adversarial system does. But once the contract is signed, the two systems are the same.

I visited Japan in 1965 when there was still little contact between their industry and ours. I was struck by the number of engineers whom they could fling into solving any problem which might arise. It made certain the problem was solved, though their solution might be laboured rather than elegant. I became friendly with my opposite number, who had just worked very long hours with no hope of any reward – in those days promotion was strictly by seniority. "What motivates you, then?" I asked, and he replied "I am an engineer. Engineering is an honourable profession". How do you compete with that?

SUMMARY

- **In competitive tendering offers have to be put together and priced quickly – mistakes can and do happen**
- **The contractor will offer something to satisfy the enquiry specification, whether that specification is technically sound or not**
- **Many purchasers don't have the expertise to know which offer is the best: choosing the lowest priced tender can be quite wrong.**

Figure 6 *Competitive bidding*

16

HOW THINGS CAN GO WRONG – 3

Chapter 11

I got this example from working as an Expert Witness in a large lawsuit in London's High Court.

The background was this: a large chemical works in the Midlands needed a constant and reliable supply of steam for its processes. The client was an Operating Company which had been formed in order to build a gas-fired power station to supply this steam. The plan was to generate steam at high pressure and use it to generate power before going over the fence to the Chemical Works. This combination produces both steam and power at greatly reduced overall cost.

Chapter 17

If the steam supply were to fail, however, the chemical works would have to shut down. If the reaction tanks and pipelines are allowed to cool, they set solid with polymer, and it can take weeks to clean them out. Reliability is obviously important.

The client engaged a well-known consulting company to write the spec for a turnkey contract to build this power station. The spec was generally functional, but it did include detail for some of the

As I said earlier, expert witnesses are engaged by solicitors acting for companies who are engaged in civil lawsuits which involve specialist knowledge. In complex problems there might be several pairs of experts, each dealing with one aspect. The expert must be totally truthful but will naturally stress whatever favours their personal side of the argument. The two experts each write reports which they exchange before they meet in the hope of agreeing on as many points as they can.

Sometimes there is no agreement at all, but I once had my opposite number (an old friend) come to the meeting in total agreement with my report. "There was really no need for us to meet", he said, "but I wanted an outing and to say hello to you. This project was an utter fiasco, and that's it. Let's go and have a beer".

If you get the chance and can spare the time, expert witnessing is a great experience. It is splendidly well paid, like everything to do with the law of course, and you will discover that top lawyers are great people. It cured me of an engineers' prejudice against that profession.

major items. Several contractors submitted offers for the job. When they were examined by the consultants, the cheapest offer was found not to measure up to the standard required by the specification and was thrown out on that account.

It also transpired that the contractors' prices for all the offers came out at more than the client's budget, and that included even the cheapest one, which had been thrown out as non-compliant.

The client's MD and the CEO of the contractor who had made the cheapest offer had worked together before and were on good terms. The two sat together and went over the detailed spec which was the basis of the contractor's offer. They cut out everything not immediately vital to the operation of the power station (like stand-by equipment etc). When they had finished, they had reduced the contractor's price by 7%, and brought it within budget.

The consultant, sensibly, would have nothing to do with this, and withdrew – Client and contractor were on their own.

> When I was in court on behalf of an American company, there was discussion about cooling water flowing in a 1000mm diameter pipeline. A witness explained that they lowered a pitot tube into the feed pipe to establish the flow profile across its diameter. This, he said, would be nil at the walls rising to a maximum in the centre. The judge, who generally said nothing, suddenly interrupted. "Don't tell me that the flow in this pipeline is streamline. At that diameter it has to be turbulent, so you must be wrong". The Americans couldn't believe it! A judge who knew his hydrodynamics! With technical problems at home, they said, we have to explain everything from first principles.

The contractor was given the order, based on the copy of the specification which the two of them had slashed. It was a photocopy of the contractor's original offer with the crossings-out and notes which the two of them had made on it. Some of these were not too clear, and one or two were actually contradictory.

It was not a good basis for a multi-million project:

- The original offer had been turned down by the consultant as 'non-compliant'
- They had taken a great deal out of that, presumably making it even more 'non-compliant'
- The resulting document was neither clear nor consistent.

Not surprisingly, a great deal went wrong. By the time the station started up, the client's original MD had left. His replacement found things unsatisfactory (which indeed they were) and – unwisely, as it turned out – instigated a lawsuit against the contractor.

One of the more important failures was that the boiler feed water plant (my specialised field) was too small, had no back-up capability when one or other of its components had to be taken out of service for maintenance, and the treated water storage tank was too small to maintain the supply for such periods. Another was that the plant generated a noxious effluent for which there was inadequate provision. And that was just the boiler feed water plant.

There were other problems such as, for example, it was claimed that the cooling tower wasn't up to its duty – other expert witnesses were engaged for that.

The boiler feed water plant was designed and built (very cheaply, no doubt) by a Canadian subcontractor, so communications got fouled up, and there was inevitable delay in sending people to sort the plant out after it had started up. That didn't help.

The actual chain of events went like this: the contractor had arranged a Performance Guarantee with his bank. This means that the bank undertakes to pay a sum of money to the client if he claims the contractor has not performed the contract properly, and debits the contractor for it. The bank must pay up on demand, without judging whether the demand is justified or not. It is then up to the contractor to bring an action to recover the money. So it was the contractor who brought the action, but the purchaser had effectively forced him to do it.

Deionisation plant produces waste streams of acid and caustic, and are usually designed for these streams to neutralise one another in an effluent tank before discharge. The tank was actually too small, and there were times when its contents were quite acid. The client got the Health and Safety Executive to make an issue of the resulting danger. A good friend of mine was engaged to deal with this aspect, and it proved his finest hour. He produced a bottle of 2% sulphuric acid in court, poured it into a beaker and stuck his index finger into it. "How long would your Honour like me to keep my finger in it?" he asked. The judge smiled, told him to take his finger out, and we heard no more of the dreadful dangers of the effluent tank.

Still worse, the water treatment plant had been based on a design which my company had abandoned 20 years before. I was working on the contractor's side and would say to the solicitors, "This is the lousiest plant I have ever seen". They would reply, "Yes, but does it conform to the contractor's offer?" Actually it did, because the offer had made no mention of its grossly excessive chemical consumption. So I had to say, "yes, I suppose it does". "Well, in that case be so kind as to keep your opinions to yourself. All we have to establish is that the plant conforms to the contractor's offer".

I have a theory on why the client's original MD commissioned a project which he must have known would give serious trouble. Perhaps he calculated that the plant, once it was running, would prove so profitable that it was worth pressing on with building it while he had the opportunity. He may have reckoned that the revenue which it was going to generate would be so high that it would more than pay for all the retro-fitting which would undoubtedly be necessary. It's just a theory of mine, but if it is true, it's hard to say that it was bad engineering. The second MD however, the one who instigated the lawsuit, was wrong, and to prove it he lost both the case and his job.

We won, but in my view both sides emerged pretty badly from the shemozzle. What is the lesson to be drawn from this? The specification on which the contract between client and contractor is drawn up is the key. Once a contractor has the contract, the prime object is to build what the spec says, at the lowest cost. If the outcome is no good, that's not the contractor's fault – not in law it isn't – it's the specification's.

"A lawyer will do anything to win a case; sometimes he will even tell the truth." – Patrick Murray, American comic.

Summary

- **A contract is based on the specification which has been agreed between the purchaser and the contractor**
- **The contractor's duty in law is to meet that specification**
- **If the specification is incorrect – not what the purchaser wanted – then it is the purchaser's responsibility.**

17

OTHER TYPES OF CONTRACT

Traditional contracts

Traditionally contracts are generally of three types:

1. *Supply only* in which the contractor has to supply and deliver certain specified goods – for example, a factory built skid mounted pump set – to a specified delivery point at a specified time.
2. *Supply and install*, where the contractor is required not only to supply the specified goods – for example, an air handling unit for an air conditioning system or underground pipes and fittings – but to install them and, often, commission them.
3. *Construction* in which the contractor is required to construct exactly what is specified in the contract.

Selection of the contractor is by competitive tendering and the lowest bidder wins the contract even if a mistake in the tender price is made. The conditions of contract generally promote a confrontational or adversarial relationship between the purchaser and contractor with the result that neither party is really happy with the result.

Chapter 15

To overcome some of the intrinsic problems of competitive tendering, various approaches have been developed to find a way of giving both purchaser and contractor a common interest in producing a result which represents the best solution at the lowest price.

Reimbursable Contracts

Since the mid 1980s, particularly in the process industries, there has been a move towards 'reimbursable contracts' in which the contract price is not fixed but the contractor is reimbursed by the purchaser for the work done and the items purchased by the contractor. The way these contracts are awarded is more complicated than conventional competitive tendering. The purchaser selects a short list of pre-qualified contractors and issues a performance specification, setting out what the goals are.

The contractor has complete freedom to propose any solution. The contractor may specialise in a particular technology (Specialist contractor); or choose from a wide variety of technologies (Main contractor) on the market and employ specialist subcontractors to supply them. Because a variety of contracting skills are needed in this type of contract it is quite common for a consortium to be set up to tender for this type of contract. This is a separate company in which a number of contractors have a share. In this respect it mirrors the Operating Companies that are frequently formed to start, finance and execute a project.

Once the contractor has been appointed, the contract usually proceeds in two stages. In the first stage the contractor prepares a Front End Engineering Package which has enough design information to produce a more accurate cost estimate. The design is agreed with the purchaser and the cost estimate becomes a Target Cost for the second stage of the contract.

> Let's take an example from an industry I'm familiar with. Suppose a water supplier wants to build a new water works. The purchaser (the water company) issues an enquiry document describing the site, giving information about water quality and the quantity of water he wants to supply, the ground conditions and similar information. It will also give the selection criteria – this may be capital cost, total cost, robustness of plant, footprint, environmental impact, and so on.
>
> Each of the prospective contractors prepares a proposal describing how the job would be done – what process technologies would be used, what the buildings will look like and estimated capital and operating costs for the proposed water works. The contractor can propose whatever is likely to be the best solution: maybe a combination of traditional processes like clarification, filtration and disinfection or, perhaps, a high tech solution like reverse osmosis. The purchaser selects whichever contractor is thought to have the best solution based on the selection criteria.

The second stage of the contract is pretty much like any other design and build contract except that the purchaser is much more closely involved in all the decision making. The target cost estimate identifies the cost of each direct cost item – materials, subcontracts, and engineering, procurement and contract management man-hours at the contractor's cost centre rates. It will also identify an agreed mark-up (that is a percentage addition to direct costs) to cover the contractor's overhead. This might typically be around 15% so each direct cost item has 15% added to it as contribution.

The 15% mark-up can be compared with the 20–25% contribution made by contractors in pricing competitive tenders. Of the various differences between the two methods of managing a contract, the most important is that reimbursable contracts relieve the contractor of most of the commercial risks associated with conventional contracts. With lower risk, the contractor can afford a lower contribution.

As the contract proceeds the contractor expends man-hours, buys materials and places subcontracts. Each item of expenditure is accounted for in detailed contract management accounts that both the contractor and the purchaser can review at any time. This is called open book accounting and both parties know exactly what money is being spent and how much profit the contractor is making – a situation with which many contractors are not comfortable. Progress is monitored weekly and any variations from the target cost have to be agreed with the purchaser.

Design and construction problems occur in most contracts. In conventional contracts they are usually a problem for the contractor who would then try to claim the cost back from the purchaser as an extra. The purchaser would try to resist any additional cost. In reimbursable contracts the purchaser and contractor are part of the same team and have to work together to solve the problem.

I was involved in a landfill leachate treatment plant contract where everyone thought the ground conditions were good. During the contract it became obvious that the site would need to be piled - an expensive option. In a traditional contract the contractor would have had to pile the site and hope to claim some of the costs back from the purchaser as an extra. But in this contract the contractor and purchaser had to work together as part of the same team to find an acceptable solution to the problem. The solution involved some re-design to spread the load and a more robust foundation that didn't need piling.

A successful reimbursable contract requires both purchaser and contractor to have technical expertise: it's not a matter of placing a contract and leaving the contractor to get on with it. The purchaser becomes part of the team, for which they need much the same level of knowledge of the technology as the contractor; without that it is difficult for meaningful discussions to take place prior to technical decisions being made. I mentioned earlier that purchasers quite often don't have this specialist technical expertise, so it is not unusual for the purchaser to employ a consultant to fill in the gaps and act on their behalf. A successful reimbursable contract also requires a degree of trust between contractor and purchaser which is still alien to most of the UK construction industry.

As we have seen, special conditions of contract are applicable to these reimbursable contracts, the most widely used being the Institution of Chemical Engineers' Green Book Conditions.

A major advantage of this type of contract is that it allows 'fast track' projects (where the design is not finalised at contract award) to be constructed. As the design develops, the contractor is paid for the engineering man-hours that are used at the agreed rate.

A different approach

More recently different approaches are being tried. These days, contract types also include:

- design and build (D&B)
- design build finance (DBF)
- design build operate (DBO)
- design build finance operate (DBFO)
- build own operate (BOO)
- build own operate transfer (BOOT).

In D&B contracts, the contractor is responsible for the design as well as for the construction. This relieves the purchaser of the responsibility for designing the project (or paying a consultant to do so) but means that the tenders received may all be based on different designs and this makes tender adjudication a much more complicated procedure. On the other hand, it gives the contractor the opportunity to offer an innovative design that couldn't have been offered under the traditional build only contract.

In DBF contracts the contractor is again responsible for the design, but also provides financing for the project. This means that the purchaser doesn't have to pay interest on a bank loan (but does pay for the contractor's loan) and this may be beneficial as interest payments will not appear on the accounts; and the contractor may borrow money more easily or at a preferential interest rate.

DBO contracts are a bit more complicated. Here the contractor not only designs and builds the project but also operates it. In the case of a road the contractor will have a maintenance contract for a period of, typically, twenty five years.

If it's something like an effluent treatment plant the contractor will provide all the necessary operating staff and support services. The benefit to the purchaser is that they don't have to worry about providing specialist operating services, and a contractor with a number of operating contracts should be able to reduce costs by centralising common services.

DBFO contracts are the same as DBO contracts but the contractor also provides the finance.

BOO contracts are essentially the same as DBFO contracts but in a BOO scheme the contractor retains ownership of the project and would write off the value of the capital cost in the operating charges over the contract period. This means that the purchaser effectively buys whatever the project produces. In a word, it's outsourcing. Another example is the setting up of combined heat and power (CHP) projects. Here a consumer of steam and electricity – say an oil refinery – scraps its boiler house and buys both steam and electricity from the CHP plant operator at an agreed price on a long term contract.

In the water treatment business, the outsourcing approach was first used in Silicon Valley in California. Making computer chips needs ultra-pure water – water so pure you can't measure the impurity levels in it. The chip-makers have their own highly specialised technology. They don't know, and don't want to learn, about designing and operating plant for making ultra-pure water. Instead they give a specialist contractor a bit of land to build a plant by the side of their works, and buy the ultrapure water on a long-term contract.

BOOT schemes are essentially the same but, at the end of the contract period, the whole thing becomes the property of the client.

The responsibilities of the two parties are summarised in the matrix below:

TYPE	**DESIGN**	**CONSTRUCTION**	**FINANCE**	**OPERATION**	**OWNERSHIP**
Build only	purchaser	contractor	purchaser	purchaser	purchaser
D&B	contractor	contractor	purchaser	purchaser	purchaser
DBO	contractor	contractor	purchaser	contractor	purchaser
DBF	contractor	contractor	contractor	purchaser	purchaser
DBFO	contractor	contractor	contractor	contractor	purchaser
BOO	contractor	contractor	contractor	contractor	contractor
BOOT	contractor	contractor	contractor	contractor	contractor

The last five of these different methods share a mould-breaking characteristic: contractors do more than provide a bit of hardware – they build and operate the project; that is, they provide a service. This has far-reaching implications.

The skills needed for plant operation are different from those needed for design and construction so the consortium approach is widely used in these various types of contracts. Chapter 12 The consortium generally takes the form of an 'Operating Company' created specifically for the purpose. The structure of the consortium will reflect the risk that each party is taking and the scope of their input to the contract. Since many of these schemes call on the contractor to find the capital, it is common for the banks which provide it to become partners in the consortium.

Under a conventional design and build contract, which is awarded on capital cost, the contractor will generally engineer the plant to the lowest capital cost, which will usually mean higher operating costs for the client. For example, in choosing the diameter of pipelines, the contractor will normally select the smallest practical diameter. This reduces the bought out cost, resulting in either a lower tender price or an improved contract contribution. On the other hand, the power required for pumping will be higher so the plant will be more expensive to operate. Chapter 24

A design build and operate scheme will generally lead to a higher capital cost for the purchaser because the contractor will try to maximise the capital cost (which will be paid by the purchaser) and minimise the operating costs for which the contractor will be responsible.

As we have seen, conventional contractors only have their working capital, so they can't raise the money necessary to finance large projects without help. The way they overcome this is to become shareholders in an Operating Company which raises the capital by issuing shares. Chapter 6 The power station at the chemical works that went wrong was financed by such an Operating Company created for the purpose. It was led by a company who own and operate power stations around the world and the shareholders included the chemical company which was to buy the steam, as well as a bank. However, this was not a DBFO contract – the Operating Company went out to conventional tender. Chapter 12 But the power station in the East Midlands project that I mentioned before was owned by an Operating Company formed for the purpose, and in this example the contractor was a major shareholder.

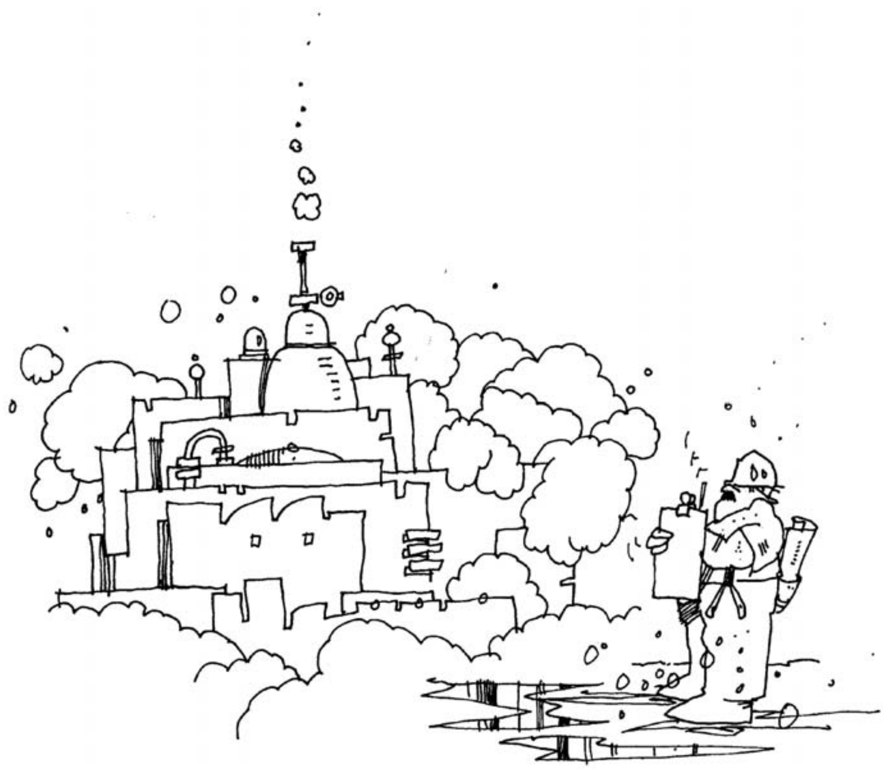


Figure 7 *A bit more time on design is worthwhile…*

The design, construction, and long-term operation of the project are all in the same hands. There is therefore no point in skimping at either the design or construction stages if it is going to bring about an increase in the costs of operating or maintaining the project. In theory at least, this makes the Operating Company aim at the lowest Life Cycle Cost. There is no longer any need to devise or accept a bad or skimpy spec, or to cut corners in its construction – at last the object should just be to do a good job.

Chapter 24

I have been told, however, that even in DBFO contracts the construction people will sometimes cut corners, like they used to do before. That's either because the Operating Company's accounts system is compartmentalised in some way which makes the construction people look good if they can report low construction costs. Or (very likely) it is because the bad habits acquired in a professional lifetime are hard to change.

The DBFO contractor becomes the owner of at least a part of the operating company in the form of shares. Once the job is up and running, the financial future of the operating company becomes fairly clear. If it is successful the shares can be sold (at a profit, of course) and frequently are. The contractor has acquired a fixed capital base - in fact, the entire character of the company has been changed. The company now owns fixed capital which gives it stability and which banks consider as security for loans; it has a steady income for many years to come, and no longer survives only by going from contract to contract; it no longer provides a finished product, but a long-term service. My friend, the contracting companies' specialist in the big bank, thought this was very much a move in the right direction. As a banker, he was very pleased at the stability and the long-term income which DBFO brings.

PFI

Governments worldwide are increasingly turning to Private Finance Initiative (PFI) schemes, under which public services like hospitals, prisons, universities and roads are designed, built, financed and operated by private companies. The operating company is paid on the basis of the number of units – patients, prisoners, students or vehicles – using the facility. PFI schemes are generally very large and Operating Companies are invariably set up to for these projects.

> A typical UK PFI contract was for a stretch of road – the traffic on it was monitored and the operating company was paid so much per car. This meant something of a gamble, because the income couldn't be predicted with great confidence – it would depend on the state of business in general, and local conditions in particular. The contract also specified that if any lane of the road was closed for maintenance, the payment was reduced – an excellent incentive for sound construction.

The bad news is that many PFI contracts have gone shockingly wrong. Some well-publicised examples have cost the taxpayer dear. The ones where the Operating Company is in trouble are less well publicised. It is also true that PFI is a radical new idea which still needs to be run-in properly – at the time of writing, there can scarcely be any PFI schemes which have already run their full course. With more experience it should be possible to do better.

> The reason for the failure of at least some of these PFI contracts is the fact that Governments in general seem incapable of organising good contracts. There is a dreary record of Ministry of Defence contracts regularly going 200 to 300% over budget, and the Scottish Parliament building is now expected to cost nearly ten times the original estimate.

Speaking personally and as an engineer, I do hope that something along the lines of DBFO will emerge as a practical method of commissioning projects. It holds out the promise of better engineering. By definition, that means a better outcome for everyone.

Chapter 1

Summary

- **The traditional competitive tendering method of commissioning projects has often given bad results**
- **The last twenty or so years has seen a variety of efforts to improve matters by different forms of contract**
- **Some of these turn the contractor from a provider of hardware into a service provider, and that should, at least in theory, make for better design and construction**
- **No clear winner has yet emerged.**

18

TERMS OF PAYMENT

What are Terms of Payment?

The Conditions of Contract will include a set of agreed 'terms of payment' that detail how the contract price will be paid to the contractor. Purchasers understand that contractors have to spend most of the money that they expect to receive well before completion of the contract. This means that the contractor has to pay interest on the money and may have cash flow problems.

"Paying interest on the money" is valid even if the contractor has enough cash in the bank to be able to fund the work without borrowing. If the cash is not needed to fund the contract the contractor could have put it out on loan, to a Local Authority or Building Society for example, to earn interest. Either way interest is lost.

Therefore, except for very small contracts, it is normal for the purchaser to pay the contractor in stages as work proceeds. The purchaser, of course, has similar problems of interest and cash flow. There is a direct conflict between the purchaser, who wants to pay as little and as late as possible, and the contractor who wants the opposite. Setting acceptable terms of payment is, therefore, important to both parties. Construction contracts usually allow for payments to be made at monthly intervals against measured work completed or other 'milestones' that are defined in the conditions of contract. The sort of things that might count as milestones include completion of certain specified drawings, completion of foundations, installation of mechanical and electrical equipment and so on. Payments like this are called 'stage payments'.

Ownership

In mechanical and electrical (M&E) and process plant contracts – where much of the fabrication work is carried out off site – the contractor will probably have to spend a lot of money before anything is actually delivered to site. A typical contract might include the supply, delivery, installation and commissioning of steel pressure vessels – perhaps a boiler system. It is quite usual to provide a payment to the contractor when construction materials (typically steel plate or pipework) are delivered to a fabricator's works, provided that the materials are identified as the purchaser's property. This means that the purchaser has a lien (a right of ownership) on the materials – that is the purchaser will be able to claim them should the fabricator go into receivership before completion of the contract. Similar stage payments may be made on completion of the fabrication, on delivery to site, on completion of installation and on completion of commissioning.

The title, that is the ownership of the goods, normally passes to the purchaser only when money has been paid. The risk may or may not pass at the same time. This means that although the purchaser may own the pressure vessels before they are delivered, the safekeeping (in practice the insurance) of them may still be the fabricator's responsibility. If there is a fire at the workshop and the vessels are damaged, making good is likely to be the fabricator's responsibility rather than the purchaser's. It is, therefore, important to distinguish between title and risk in goods and at what stage each passes from one party to another.

In design and build contracts it is usual to allow stage payments against completion of all or parts of the design, typically on presentation of drawings and calculations. The copyright in the drawings will usually pass to the purchaser on payment (but the laws relating to intellectual property are beyond the scope of this book).

Delivery

It might be useful to introduce a few terms that you might come across in export contracts. In home construction contracts the contractor is normally involved in supply, delivery and installation of equipment, so the contractor is responsible for getting the equipment to site, unloading it from the truck, storing it until it's needed, moving it into position and fixing it (although there may be some argument between the contractor and the supplier about who should be paying for the transport and craneage for offloading). In export contracts the contractor's responsibilities are quite often more limited, but have to be carefully defined. This is where we need to understand the various terms for delivery.

I worked for a UK company that routinely built skid mounted water and wastewater treatment plant for export contracts. A typical export contract would be the supply of a skid mounted produced water separator for separating crude oil from produced water on an offshore platform. We would engineer and build the unit and ship it out to wherever the platform was being constructed, usually in Scandinavia.

The commonest delivery terms are:

ex-works	The contractor has to make the goods available at the premises (that's the factory where the equipment was assembled). The contractor is not responsible for loading the goods onto the purchaser's truck unless it's been agreed separately.
FAS	This is short for 'Free Alongside Ship' and means that the contractor has to place the goods on the quay next to the ship and has to pay all the costs up to that point including any export clearance costs. Once the goods have been placed on the quay, they become the purchaser's property (the purchaser has to bear any risks).
FOB	This is short for 'Free On Board' and here the contractor is responsible for placing the goods on board a ship - usually nominated in the contract - including paying for any documentation costs. Once the goods are on board the ship the Captain will issue a 'Bill of Lading' as proof, and this usually has to be presented to the purchaser to get payment released. The risk passes to the purchaser as the goods cross the ship's rail.
C&F	Means 'Cost and Freight' and here the contractor is responsible for all the costs involved in getting the goods to a destination nominated in the contract. The risk passes to the purchaser as the goods cross the ship's rail at the port of shipment.
CIF	Means 'Cost, Insurance and Freight', and is essentially the same as C&F except that the contractor has to pay the insurance premium for marine insurance against loss or damage in transit.

Other terms might include the contractor being required to pay local import duties and taxes at the destination.

In export contracts payment is often made by means of an 'Irrevocable Letter of Credit'. The purchaser arranges with the bank to provide credit in a UK bank which is used to make payments to the contractor on presentation of specified documents such as the Bill of Lading. The contractor deals only with the bank and the purchaser cannot refuse payment for any reason.

The Letter of Credit system works well but must be handled carefully. The documents presented must have identical wording to the Letter of Credit. If a word is misspelled in the Letter of Credit it must be identically misspelled in the Bill of Lading otherwise the bank will not pay.

Retention

Chapter 9

It is usual for the sum of stage payments up to completion of the contract to amount to only 90 or 95% of the contract price, the balance being retained by the purchaser for a period (typically twelve months).

Chapter 6

Chapter 12

Retentions obviously make a serious hole in a contractor's working capital. Suppose a company with a £10m turnover has a 10% retention for one year on all of its contracts. That means that, on average, it has £1m permanently held up in retentions. Given that the company probably needs about £2m working capital, that's a major financial burden.

On large contracts retentions can tie up so much cash that it can cause major problems. In this case the contractor might arrange a bank guarantee as an alternative. The contractor is paid in full but gives the purchaser a bank guarantee for the sum of the original retention. If defects are found during the guarantee period and not rectified by the contractor, the purchaser is entitled to demand payment from the bank. The bank must pay up without question and, if the contractor thinks the purchaser is in the wrong then they have to sue the purchaser for the money.

Extras

All contracts have variations during their course: work – maybe additional engineering or the supply of materials – which were not originally foreseen. The contractor will usually try to recover the costs of these variations by claiming them as an 'extra to contract' from the purchaser. The purchaser will not always agree to pay, claiming that the work should have been included in the contractor's original estimate. This issue is the most common form of dispute in contracting and will often happen many times during the course of the contract.

As far as cash flow and the audit are concerned, the important thing is not whether the work has been done, nor the contractual position with respect to fault, but whether there has been agreement from the purchaser that they will pay. Suppose a contractor has to provide additional materials which he believes to be extra to the contract but the purchaser believes should have been included. The additional materials appear on the contractor's Balance Sheet as a liability because he has had to pay for them. Only if the purchaser agrees to pay the extra can the contractor issue an invoice, and this appears as an asset. This agreement may not be given until the completion of the contract; it may not be given at all and may become the subject of protracted litigation which may take several years. Chapter 3

The principle remains that the costs are a liability on the contractor until the dispute is resolved. As we saw earlier, over-optimistic Project Managers who allocate claims for extras as assets before dispute resolution can cause major problems because, on the basis of the management accounts, those assets will appear on the Balance Sheet as work in progress and distort the true picture. Chapter 4

Some less than scrupulous contractors routinely bid low prices for contracts and employ very sharp quantity surveyors to negotiate extras through the contract period to make up the contribution that the original contract price lacked.

> "I knew we were going to have problems on this contract", the Project Manager told me, "The first thing the contractor (one of the top UK civil contractors) did was to install a site cabin with five quantity surveyors in it".

Summary

- **Except in the case of very small contracts, most contractors don't have the money needed to complete the contract without being paid part of the contract price as work proceeds**
- **If these stage payments don't cover the expenditure on the contract, the contractor has to find the difference out of working capital. That affects cash flow**
- **Retentions do that, too**
- **The purchaser also wants to nurse the cash flow and avoid borrowing**
- **A compromise has to be found at the contract stage and set out in the terms of payment**
- **Extras are a battlefield.**

19

HOW THINGS CAN GO WRONG – 4

The worst contractual disaster I ever got involved in was the construction of an effluent treatment plant for a chemical manufacturer. The purchaser wanted to employ a respected firm of consultants to carry out pilot plant trials to establish the process requirements and the design parameters. The purchaser also wanted the consultant to be involved right through the contract. An agreement was made between a major civil engineering contractor and the consultant that the contractor would take on the construction work but would employ the consultant to do the pilot plant trials and, importantly, to be the designers for the contract.

The purchaser was happy with this arrangement and, in the mid 1990s, agreed to place a reimbursable contract with the contractor, under which the pilot plants trials would be carried out, the design parameters established and a cost estimate agreed as a 'target cost'. All was going well and the cost estimate was produced at £24m. The purchaser did not have enough money and a number of changes were made in the scope to reduce the costs to about £15m.

Things started well but the contract manager was a road builder with no experience of process plant contracts. The contractual arrangement between the consultant and the contractor did not specify who was to provide the all-important preliminary engineering documentation known as the Front End Engineering Design (FEED). The contract manager decided to start on the construction without the FEED whilst the contractor and consultant argued about who should be doing what. Not a good decision.

The consultant was accustomed to working as his client's representative; that is, overseeing the work of a contractor. In cultural terms the consultant's staff looked down on contractors as intellectually inferior. But this job was different because, in contractual terms, the consultant was a design subcontractor to the contractor. It was not going to be an easy relationship.

It got worse. As the contract proceeded, the Project Manager invoked safety as an argument for some more changes to the scope, this time reinstating many of the things that had been removed to reduce the cost. When the contract manager pointed out that the Project Manager himself had asked for these items to be deleted, the response was that they were needed on the grounds of safety. Without them the plant would not be safe and the contractor's design was, therefore, flawed and the various items would have to be supplied **at the contractor's cost**. The disputes continued and the programme slipped. By now relations between the two parties had deteriorated to the point that the contract manager had to be replaced.

His successor was a more experienced man, but he misread the situation. In order to placate the Project Manager, he agreed to most of the demands in the expectation that, once the contract was back on programme, he would be able to renegotiate costs, which had by now risen to £25m. He was wrong. The Project Manager was nearing retirement, and this was to be his last project: he was going to complete it within the £15m estimate. Cost negotiations failed.

Sadly there was further bad news. The consultant (the contractor's design subcontractor), it turned out, had got his design badly wrong and many of the plant items did not work. This caused further friction and, in the eyes of the contractor's engineers, confirmed the opinion that the consultant's engineers were too academic with no practical experience.

I had done subcontract work on other projects for both the consultant and the contractor during this time, so I knew both teams and was aware of the contract's problems. Towards the end of the contract I was employed by the consultant to help tie up some loose ends. On one occasion I met the contractor's divisional director in the kitchen of the site cabin and he asked me what had gone wrong. I summarised my opinion as follows: "Your contract management has been incompetent, the consultant's design was wrong and the Project Manager is the most obnoxious, unscrupulous engineer I have ever had to deal with. It was never going to be a success."

On completion of the contract, the contractor employed a firm of Quantity Surveyors to draw up claims for most of the £10m overspend. Since they hadn't been involved in the project construction, they were depending on the contractor's site staff and the consultant's engineers to provide much of the information. I was asked to meet the quantity surveyors to add what I could to their knowledge of the project. There were six of them in a hired office about 10 metres square. The walls were floor to ceiling bookshelves packed with the files on the project. It became quite clear that their first task was to prepare the claim

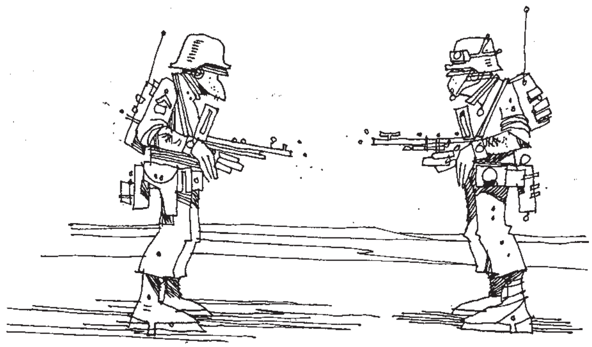


Figure 8 *Negotiating extras*

against the purchaser, but that they were also building up a case against the consultant in case the claim failed.

> "A jury consists of twelve people chosen to decide who has a better lawyer." – Robert Frost

Almost ten years after the project's inception, the contractor started litigation procedures. The purchaser not only threw out the claim but issued a counterclaim for as much again. Inevitably the contractor sued both the purchaser and the consultant. All three sides employed solicitors, barristers and other consultants as expert witnesses. By this time nearly all the people involved in the project had moved on to new companies, retired or, in one case, died. Arguments were argued, but were argued by people who had had no involvement whatsoever in the project. And when all the arguing was over and the accounts were done, the only people who had really benefited from the project were (as usual) the lawyers.

Summary

- **This contractual fiasco broke all the rules of good contractual practice**
- **Perhaps the most important lesson you can learn from it is that contractual problems are very rarely technological**
- **Mostly they are personal problems of and between the individuals involved**
- **And, of course, problems of money.**

20

PLANNING CONTRACT EXECUTION

What next?

Once a contract is signed, the rules under which it is going to be executed are fixed. At last (after 19 chapters) we can get to consider the business of actually doing it. From now on, in a conventional contract, the contractor has two main objectives:

- to get by his contractual undertaking while spending as little as possible
- to get the greatest benefit (or the least damage) to his cash flow.

> 'Rules' here has the same meaning as in sport, where your game plan aims to extract the greatest possible advantage from the rules. Over the last decades soccer fans haven't had a lot of changes to their rules, so they will be less aware of this than followers of Rugby (and, to a lesser extent Cricket). Constant fiddling with the rules of Rugby in the last 30 years has brought about huge changes in how Rugby is played. And the interpretation of the rules isn't quite the same in Europe as in the Antipodes, so players who move from one to another need to adapt. The same adaptability is needed for performing a contract. No wonder Management Games are much used in Management Courses.

The basis of the contract is the specification which was agreed when the contract was signed. It doesn't matter now whether this was part of the purchaser's enquiry, or of the contractor's offer – anyway, some details may well have been modified during the contract discussions.

Contracting is a trade which has its own specialised skills, regardless of the technology involved, whether constructing an oil refinery, or just doing the electrical wiring for it, or for building a bridge. Of course, any such project requires the specialised skills suited to its own technology. Here I mean the skills which are common to all of them – the professional skills used in executing projects.

Time is the essential component in this. Time is the one irreplaceable commodity we have, but there are sometimes ways of buying it with money. Planning is the art of organising time. In our context that means providing the labour, materials and services for the job at the right time and place, monitoring the work as it proceeds, and taking corrective action as soon as it is needed.

Any part-finished project is a waste of money for two reasons: loss of benefit from the completed work and loss in the form of interest payments on the money which has been spent. Suppose, for example, that Marks & Spencer acquire a High Street store. They expect to spend quite a lot of money refitting it but that expense is small compared to the profit they hope to make when it opens. Every day's delay in opening costs M&S a day's takings. Moreover, the money they paid for the site, and the money they've so far spent on refitting, is all costing interest. This is why shopfitting contracts are often drawn up with big bonus payments for early completion, which gives the contractor an incentive to accelerate the work.

The Plan

Making a plan consists of reducing the job to its component elements and then fitting them into a timetable. For each of its elements we need to know:

- how long it is going to take
- is its start dependent on some other job having been completed first?

And then, when we come to arrange the elements into a timetable:

- what materials, services, etc., will each element need? and
- how long will it take to procure those and when are they available?

Chapter 21

With this information (and other minor items) it is possible to set up a plan. While the purchaser's objective here will be to complete the whole job as quickly as possible, the contractor's normal objective is to reach all payment points as quickly as possible. These two objectives are usually, but not always, identical. Either way, we want to shorten the time taken for some, or all, of the job. To do that, we must first identify the sequences of elements which, have to be carried out in a sequence one after another.

When building a house, for example, building the walls needs the foundations finished, and putting up the roof needs the walls to be finished, but digging the soakaway can be done at any time. When we have identified the order in which the elements must follow one another, and how long each one of them takes, we can identify which of these sequences takes the longest time.

Once we have identified this controlling sequence, we have the 'Critical Path'. Shortening anything which does not feature on it can't shorten the whole job. There is a formal way of doing this exercise called Critical Path Analysis (CPA), which is described in Appendix 2.

CPA was developed as a formal technique during World War II in order to minimise the time it took to refit aircraft carriers. As long as they were in dock not doing their job of protecting convoys against German submarines, ships would be torpedoed and their crews would drown. This wasn't about saving time – it was about saving lives.

Appendix 2

Having identified the elements on the Critical Path, we can then consider what we might change in one or more of the components on it in order to shorten the overall time. There's no point in doing anything with an activity that isn't in the controlling sequence – it isn't going to help.

There's this chap who said he wished he had his mouth on the top of his head. Then he'd be able to put his breakfast in his hat and eat it on the way to work.

The fact that in any job there is a controlling sequence which is worth improving is the basis of CPA and it is universal. It is true for any activity which has a number of components. It should never be ignored when putting together a plan, even if it isn't worth doing a formal CPA on it.

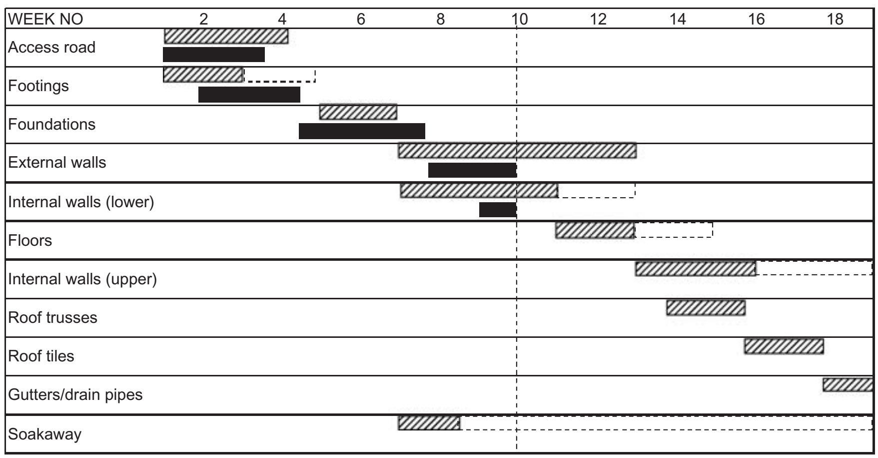
However formally or informally the plan is laid out, the best way is to start the process with the finishing point and work backwards. At every stage in the process you then have to ask "What needs to be finished and available before I can start on this element?"

The next stage is to look at the activities on the Critical Path and see whether it is possible to shorten the time each of them takes. If that is possible, it may be that another path emerges as the longest – criticality has been transferred. In a really complex job like building an oil refinery, the network is so complicated that this is best done on a computer. There is a range of software programs available for project management. One of the best, and the one used most widely by larger companies on large projects, is Primavera. Other programs include Pertmaster, Open Plan and Microsoft Project.

To make coffee with my cappuccino machine, my wife clears out the old coffee and loads the machine with fresh, inserts the cup into the machine, fills the machine with water, puts milk in the cup, switches on, and when the coffee starts running through, froths the milk with the steam jet. She then sugars it, and stirs. It all takes 6½ minutes. I switch on first, quickly fill the machine with water before it overheats, and can get all the other things done before the coffee runs through. I also put sugar in with the milk to get it stirred with the frothing. Total time, 3½ minutes.

I've had my leg pulled for being so fanatical about time, but our time on earth is limited, and that's all we've got. If I make coffee twice a day, 300 days in the year, it saves 40 hours a year – a working week. Time saved in which I can entertain myself, or just be idle – if you want to waste time, do it on purpose, not because you're being inefficient. So anything you have to do frequently, however simple, is worth planning properly.

Simple jobs don't need the full rigmarole of CPA. The commonest and most efficient aid to planning them is the bar chart. The diagram below is a simplified bar chart for building a house. The top line shows the calendar for the time in which the job is to be done. Having broken the project down into its component activities, each component is assigned a horizontal line on the chart. The hatched bars show the planned times when the various jobs are to be done, with the dotted lines showing the 'float' for the job. The solid bars underneath show when the job was actually done, allowing the Project Manager to monitor progress against the plan. This chart shows actual work completed in Week 10.



The first attempt at drawing up the chart might have 'external walls' starting at the time that 'foundations' finishes and 'roof trusses' starting when 'internal walls' is complete. It is obvious that these activities are in the controlling sequence. The gutters and drain pipes have to be installed after the roof tiling is complete but the soakaway into which they discharge can be done at any convenient time, so it is not part of the controlling sequence. But while laying bricks itself can't be speeded up, you could shorten the critical path by starting on bricklaying as soon as enough of the foundations is ready to make it worth while.

I use house-building because everyone can understand it, and because I have an excellent example from personal experience. It demonstrates not only how to plan a job, but how – when things go wrong – it may be possible to get back on plan by spending a bit extra. This is called 'crashing the plan'.

When we started a major extension to our small cottage the weather was so awful that the work got badly behind. The contractor (a qualified Civil Engineer, as it happened) came one day and said: "Your architect's plan has a reinforced concrete slab over the whole extension to form the first floor. We'd have to finish that before building the 1st floor walls, and put the roof on after that. Shuttering, and reinforcement, pouring concrete and waiting for that to set will take so long we wouldn't get the roof on before Christmas, when outdoor work has to stop until March. It means you'll move in three months late. I'll have a cash flow problem, and I won't have any work for half my staff for three months, so I'm likely to lose them. But I could use pre-stressed concrete planks instead of concrete. Your architect says he's happy with that. They cost more, but I'll bear the extra cost because it's worth it to me".

It went swimmingly. The planks turned up on a lorry, together with a crane. They were lowered into position in a day – except one, which was dropped and broke. A replacement turned up and was put in place next day. Laying bricks for the 1st floor walls began at once, the roof was up and weatherproof well before Christmas, and we moved in at Easter.

The great virtue of bar charts is that they are clear and easy to read at a glance. Software is now available for setting up a bar chart on the computer. If you have a chart hanging on the wall, you can mount it on a board whose top has notches cut in it, one for each week. Every Monday you move a bit of string with a weight at the end of it and hang it from the correct notch to show the date. (This sophisticated extra is actually quite rare.)

The contractor and the purchaser do not necessarily have the same aim when planning a job: the purchaser wants the project finished as quickly as possible, in order to benefit from it as soon as possible, only having to raise the money for the shortest time necessary. It would be a good thing if the terms of payment in the contract were set so that the contractor has the same objective: in projects where the contractor only gets paid 90% of the contract price on delivery of the plant to the purchaser's site, he will be as keen as the purchaser to get on with it, and might even spend a bit more to accelerate the work.

There are (rare) occasions when a contractor might want to slow a job down. This could happen if a big payment is due from contract A, at a time when contract B needs a large sum spending on it. The contractor may deliberately slow down on contract B so that the money from contract A arrives before the bill for contract B does. This way, the contractor avoids being caught with a cash flow problem between these two events. I think some builders did this to me once, and I wasn't very pleased.

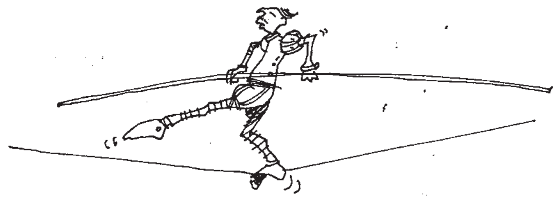


Figure 9 *Critical path*

Summary

- **The longer a project takes to finish, the more money it costs**
- **The terms of payment on a contract should be aimed at speeding things up – sometimes it is worth spending more to achieve this**
- **Every complex set of activities has a Critical Path which controls the minimum time it takes: speeding things up means shortening the activities on that path**
- **That could lead to another path becoming critical**
- **There is a variety of planning tools available for project engineering.**

21

PROCUREMENT AND MONITORING

More planning

Planning doesn't end with the creation of a pretty chart which shows what should be happening in the future.

Planning is intimately connected with purchasing. The plan for the project gives the purchasing department the times at which the various materials and services will be needed. Ideally everything should arrive exactly when it is wanted. Getting materials too late is obviously bad, because it delays the whole job. Getting them too early is also bad because it may lead to problems of storage. If materials have to be stored, that in turn could mean double handling and yet more unnecessary cost. And if goods arrive on site early, so will the invoice for their cost, which is bad for cash flow. Services, of course, must be on time.

How Procurement Department's work

Materials are purchased and subcontracts placed by the contractor's Procurement Department (or some such similar name). This works like the purchaser in the main contract. first the design engineers have to write a specification for the material required and then a document called a 'requisition' needs to be raised – this is an instruction to the Procurement Department to buy the material. The Procurement Department sends out tender documents (they usually send a copy of the main contract documents and expect subcontractors and even material suppliers to accept all the conditions of contract). When the tenders are received they are passed back to the engineer who wrote the requisition and a tabulated evaluation is prepared (usually called a 'bid tab') to ensure that the comparison is on a 'like for like' basis and decides which is the best option. There is sometimes disagreement between Engineering and Procurement because their objectives are different: the design engineer wants the best, whilst the procurement officer wants the cheapest.

Having decided where to buy the material or service, they look at the contract programme to decide when to place the order. They have to arrange with suppliers exactly when they are supposed to deliver. When the due date of critical items approaches, they will contact the supplier again – putting the 'chasing' into 'purchasing'. And Procurement Departments should know which of their suppliers are reliable in this respect, and which are not, so they know where they have to apply pressure.

All plans go wrong, some more, some less. So a vital function of the planning department is to monitor actual performance against the plan, and if there is a significant delay, get some action. Unfortunately this is where many projects fail to get the service they need. There are two ways in which this can fail, and often does.

For a particular contract we wanted to purchase valves from a top manufacturer because we knew they would do the job, but our Purchasing Department insisted on competitive tendering and managed to save 10% by going to another supplier whose valves just met the specification. The Purchasing Department were given a pat on the back for their efforts. The site engineers, who subsequently had to replace all the valves because they failed, were given a severe bollocking for overspending.

I once worked as a kind of management consultant in ICI, then a much bigger company than now. They had installed a scheme for the maintenance staff at the huge chemical works at Billingham, by which staff were paid bonuses for finishing work in the time estimated for it. But the most experienced staff, comprising one-seventh of the maintenance work force, had to be taken off direct work to do all that estimating. So I was surprised to hear it was a huge success and asked the man who had installed the system why. "Simple", he said, "you know what a vast place Billingham is – people just get lost there. We'd send a crew out to replace a pump, say, and they'd get there to find the crane hadn't turned up. Ah well, they would say, and settle down for a game of cards until it did, which might be the next day. With the bonus scheme in place, it means they're losing bonus, and someone immediately gets on the phone, saying 'where the **** is the crane?' "To be honest, it's a crutch for slack management. But it's a very effective crutch".

Communications

The first is the speed with which information can be gathered and transmitted. The battle scene is the site where construction or fabrication is actually going on. The headquarters, where the planning department sit, may well be a long way away – either physically or functionally, or both. That can lead to long delays in transmitting information back to headquarters, and orders to the front line again. Quick communication is essential. If the timetable looks as if it is going to get bogged down, then it's not much use finding out about it a couple of months later.

In the major battles of the Napoleonic wars, massed cannon firing with black powder generated great clouds of black smoke (gunpowder is expensive nowadays. People who re-enact these battles today load their cannons with as much powder as will give a satisfactory bang and flash of flame, and they load some flour on top of that to yield the authentic amount of smoke.) Once the battle was under way, the commanders couldn't see much of what was going on. By the time a despatch rider had galloped to the scene and back again, it would probably be too late to give useful orders. Communication was so slow that some of the fighting was pretty well out of the commander-in-chief's control. No wonder Napoleon said he didn't want good generals – he wanted lucky generals.

Supposing, however, the news does get back quickly enough for useful action to be taken. The trouble is that in this sort of situation "taking action" generally means spending money. You would expect that because the job was originally planned to incur the lowest cost, so any change from it will probably cost more. Action usually means bringing on extra resources, or a more expensive method of doing the job or putting staff on overtime, or something like that.

Maybe the person in charge of the job at the sharp end knows that at some modest cost the delay could be covered and so save a much greater loss. Quite often that person hasn't the authority (or the nerve?) to spend the extra.

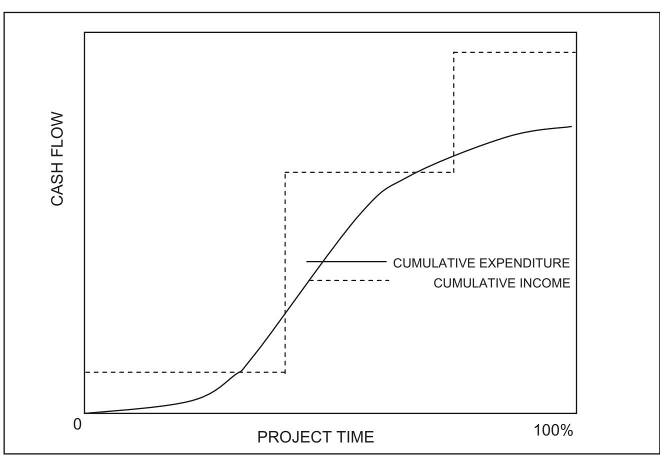
My company installed a boiler feed water plant for a new power station in East Anglia. The power station people gave us the date at which it was planned to fire up the boilers and we were working to that. The purchaser (who had a turnkey contract for the whole project) had overlooked the fact that cleaning the boilers also called for water purified to the full specification. We were already struggling to meet the original target date when we discovered that the client really needed earlier completion. But no one suggested that they would make it worth our while to do something to reduce the delay. Maybe something like this reason was the cause?

Figure 10 *Communication is a priority*

The S curve

The cumulative direct costs on a contract tends to follow an S-shaped curve, starting at a fairly low rate then increasing sharply as materials and subcontracts are procured, then levelling off as the contract nears completion.

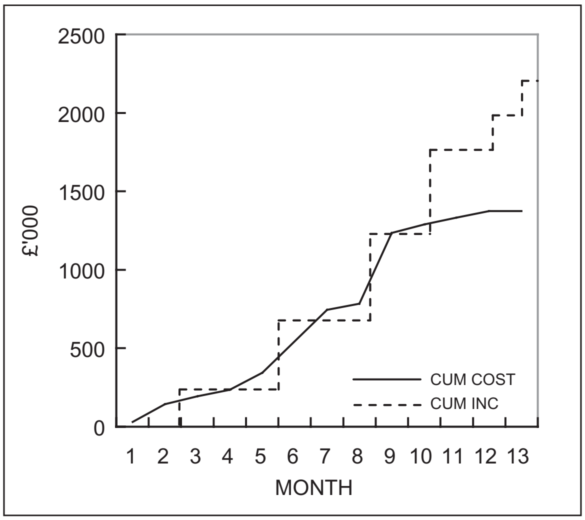
We've seen how the terms of payment define when cash will be coming in, so we can plot a cumulative income curve for the contract.



Superimposing the cost S curve on the cumulative income curve shows where cash flow is negative (where the cumulative income line falls below the S curve) and where it is positive (where the cumulative income line is above the S curve), helping us to plan procurement so that we can ensure a positive cash flow.

Of course, real S curves don't look quite so perfect. Here is the S curve for the contract that we looked at earlier.

Chapter 9



Summary

Good planning consists of:

- **Taking an overall view of the project and establishing a programme for both execution and cash flow**
- **If possible setting out the plan in some way which is easily understood – the bar chart is ideal for this if the project isn't too complex to show the plan clearly**
- **Working closely together with procurement, to make sure that goods and services turn up at the right time and that money is spent in a way that controls cash flow**
- **Monitoring progress as the work proceeds and getting a quick report of any delay back**
- **Having an organisation in which the news of significant delay gets to someone who has the authority to take any necessary action.**

22

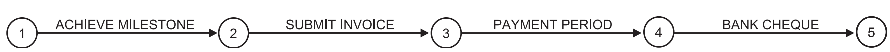
PAYING AND GETTING PAID

What's the problem?

After years of painstaking research, I can reveal that no one likes paying bills. And also that if they do have to pay, they prefer to pay as late as possible. This applies as much to purchasers and contractors as to anyone else. In the relationship between them, the purchaser wants to pay as late as possible, and the contractor wants to be paid as early as possible. The battle is always on.

Engineers may think that once they have completed the actual construction, getting the money into the bank is none of their business. In fact they still have a vital role to play.

Getting paid is yet another procedure which can be divided into elements which have to follow one after the other, but it only has one path, every element of which is critical:



1. The contract specifies when and how much the purchaser pays the contractor
2. The contractor achieves the specified milestone
3. The contractor issues an invoice for the amount due
4. There is a specified period within which the amount is due to be paid
5. The purchaser pays.

The Contract

The terms of payment are part of the contract and must therefore be settled before the contract is signed. Sometimes this arises during the final negotiations. I can remember one occasion when everything (including the price) was more or less agreed and ready for signing, when the purchaser's purchasing officer changed the terms of payment in the contract documents to make them less favourable for the contractor. When everyone in the contractor's company had already been told that the order was in the bag, this was psychologically hard to resist. It seems too trivial a matter for us to start raising objections at this stage – it's not as if they were demanding a price cut!

But actually, of course they were. If the purchaser pays smaller or later instalments than the system on which the price was calculated, the finance costs are saved and passed on to the contractor. The purchaser also puts additional load on the contractor's working capital.

Achieving the milestone

When the contractor reaches one of the milestones set out in the terms of payment they must demonstrate formally that the milestone has, indeed, been achieved. This formality takes various forms – a measurement by the quantity surveyor; or a certificate that the work has reached the agreed stage in the construction programme, or (at completion of the project) passing some form of acceptance test; or it may just be the end of the guarantee period. As a rule, there is some piece of paper to be signed by the Project Manager.

> A successful project depends on good cooperation between purchaser and contractor. It is common experience that once a contract goes sour, it will go comprehensively sour, because relationships become strained even if they weren't strained before. Bad relations between the two can of course be the fault of either side, or of both, but the contract manager should have a better approach than the Project Manager, because it is an important part of professional expertise.

Naturally it is essential for the contractor's team to realise the urgency of getting faults and omissions corrected so that the purchaser has no reason for refusing to sign the certification. If site relations are bad, for whatever reason, it can be quite hard to get this bit of paper, because the purchaser will delay it on principle, and insist that every last detail of the contract has been met, however unimportant it actually is.

The personal qualities of the contract manager are crucial. Suppose the contract manager claims the work has reached a payment point, and is going over the facts on site with the Project Manager. Some minor faults will always become apparent and, however trivial they may be, could be used as an excuse to hold things up. When these are pointed out to the contract manager the reply might be "OK, I'll get that fixed before the end of the week". If an atmosphere of trust and goodwill has been created, and the Project Manager is confident that it will be done, they will agree that the payment point has been reached, even though there may be nominal justification for refusing to sign the certificate.

The CEGB had a near-monopoly in our field and could dictate what terms they pleased. One contract specified that the work had to be carried out "to the Engineer's satisfaction" and the CEGB's man insisted that the ¾" nuts on all flanged pressure vessels were squared up before he was "satisfied". On another contract they wouldn't let us test the chlorination equipment because the chlorinating plant hadn't been painted with the official colour coding for water, chlorine, etc. But they wouldn't let the painters in to the chlorination plant house to paint it because the equipment hadn't been tested. Oh yes, it was all in the specification on which the contract rested.

Some purchasers devise complicated procedures before that can happen, but if they have been agreed as part of the contract, they have to be gone through.

This is what the NCB (the nationalised coal industry, when we still had a coal industry) did: The contractor's site engineer would get the acceptance paper from the NCB engineer in charge of the site. He had to submit this to the local area office for approval. They sent it back to the contractor's engineer (second-class post, of course) who had to send it back to his head office, who issued an invoice which had to go to NCB headquarters in London. Perhaps this astonishing rigmarole just served the NCB's bureaucratic nature, but it seemed to us that it was just an excuse to delay payment.

Real and virtual money

As far as the Balance Sheet is concerned, an invoice which has been issued is an asset to the company. In other words, as far as the Accountant is concerned, an invoice is considered to be paid as soon as it is issued. Real life isn't like this. Most companies operate on a system known as 'net cash monthly account' which means that they will settle all invoices received before the end of a month at the end of the following month. Even this is often impracticable because, in large companies with computerised accounts departments, the payment procedure can take longer. So a contractor's invoice that has been issued is like virtual money. It's an asset but it's not actually there in the bank, so it can't be spent. It only becomes real money when the purchaser's cheque is in the contractor's bank.

When a company receives an invoice it has to verify that it is correct. This means that the Accounts Department have to find out who in the Procurement

Department issued the Purchase Order against which the Invoice has been raised. And that person has to check with the engineer who raised the requisition that the goods or services described on the Purchase Order have, in fact, been supplied. Often the Accounts Department is in a separate office or even a different town from the procurement department and the engineer may be on site, so this checking cycle may take some time. In addition, many companies only issue cheques at the end of a month (a computerised 'cheque run') so if payment of an invoice is not approved by, say the 27th of the month, the supplier will probably have to wait for approval of his invoice until the end of the next month and get paid at the end of the month after that.

So far we've looked at payments from the purchaser to the contractor but the contractor's cash flow is also dependent on payments from the contractor to the suppliers and subcontractors and so on down the supply chain. If a contractor is short of cash, payment of invoices will often be delayed until the purchaser has paid, so as to keep the cash flow positive. This means that the supplier, who has other suppliers to pay, may have to borrow money to settle debts.

The difference between the real money (money in the company's bank account) and virtual money (debtors who appear on the Balance Sheet as an asset) is what cash flow and management accounting are largely about.

Most contracts will set out the payment period – the time between receipt of invoice and release of payment. Usually this will be one month, although sometimes it's 30 days, 45 days or even 90 days. Obviously the payment period is critical to the contractor who may have to borrow from the bank to cover the virtual money. A smart contractor will try to negotiate longer payment periods with suppliers and subcontractors than those laid down in the contract; this way the virtual money may become real money before it has to be paid.

Back in the 1960s Arnold Weinstock, who was then Chairman of GEC, discovered that there was so much money being processed by GEC that he could earn a lot of interest by getting his customers to pay a few days earlier and delaying payment to his suppliers by a few days. That way he could keep more money on deposit. Getting £500,000 from a client a week early and making a supplier wait a week for £500,000 means that the company has an extra £1,000,000 on deposit at, say 5% pa; for a week that is almost £1,000 for doing nothing. As other companies realised what was happening, this became an accepted way of doing business and the few days became weeks. The result was that many large companies made a lot of money at the expense of small suppliers who had to borrow money to pay their suppliers. The added debt burden drove a lot of small companies out of business in spite of their balance sheets looking good.

Bad payers

This is the theory. In practice, late (i.e. illegal) payment is all-too-common. Sometimes it goes all the way down a chain of contractors and sub-contractors: the purchaser doesn't pay, so the contractor simply hasn't got the cash to pay the sub-contractors (or at least the contractor claims that they haven't) and so on down the chain. The effect can be disastrous, especially on the little fellows at the bottom of the chain. They haven't got large capital reserves, can't raise a loan from their bank, and they go bust.

It is by no means uncommon for large companies to use their muscle to retain money in their account when it is due to a smaller company that lacks any means of demanding payment. I worked as a design consultant to a large civil contracting company. Although our invoices stated that payment was due net cash monthly account, the civil contractor did not pay on time. When an invoice had remained unpaid for three months I went to see the contract manager. He apologised and said that he had authorised payment of the invoice two months ago. Together we went to see the Accountant. He asked for details of the invoice, checked his records and opened the top drawer of his desk. I was surprised to see it was full of cheques. He flicked through them quickly, pulled one out and handed it to me. It was for the full amount of our invoice, signed … and dated two months earlier.

Some years ago the UK Government passed a bill intended to discourage late payment. It entitled the creditor to claim quite punitive interest rates for the period during which the payment was legally overdue. I am not aware that it has made much difference in practice. Suing a purchaser generally means fighting a bigger and richer company, and only the lawyers are likely to profit from it. It is also unlikely to encourage the purchaser to place another contract in future.

A system of payment which is mostly used in large international contracts is worth mentioning. At the time that the contract is negotiated, contractor and purchaser enter into a three-party agreement with a bank, and the bank makes the money available as it is needed. Then the money goes from the bank directly to the contractor, but the five stages still have to be gone through.

I bought some crates of claret at a wine auction, intending to split the purchase with the co-author of this book. "I'm sending you the cheque today" he told me on the phone. Next morning, no cheque in the post – why? Because, like any good businessman, he had put a 2nd class stamp on it. We know how to put theory into practice!

SUMMARY

- **Everyone wants to pay late and get paid early**
- **Contracts must set down exactly who pays what and when**
- **That still leaves many ways of delaying payments legally or even illegally**
- **Late payment by big purchasers can cause problems all the way down the supply chain.**

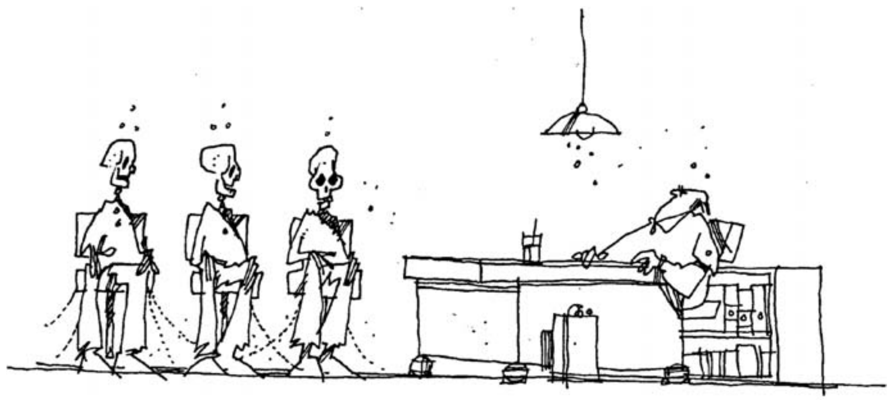


Figure 11 *Late payment*

23

CONSULTANTS

A Brief History of Engineering

We've had a Brief History of Money. In a book about Engineering and Money it's only fair to give Engineering the same treatment. This is a good time to do it because it's essential to understanding the rôle of the consultant.

The Egyptians must have been tremendous engineers to have built their temples and pyramids, but we don't know much about how they did it. The known history really starts with the Romans. They were great builders too, and achieved wonderful feats with respect to aqueducts, heating systems, and so on. But their engineering aimed mainly at military ends: building roads to carry armies and their 'engines of war' – catapults, battering rams and so on.

> I pointed out earlier that the word 'engineer' comes from Latin 'ingenium', which also gave us the word 'ingenious', and that reflects the fact that the essence of good engineering is creativity. Sadly, the word 'engine' has in English come to mean a machine or motor, which has degraded the word engineer to include mechanic, machinist, fitter and (in America) train driver.

These skills tended to be forgotten throughout the dark and middle ages. When they were revived it was again in order to serve military ends. Road building didn't approach the high standards which had been set by the Romans until early in the eighteenth century, when General Wade built the great military roads across Scotland which were intended to subdue the Highlanders (I don't think anyone has really ever managed that, to this day).

> The tradition of military engineering had never really died. The Corps of Royal Engineers claim that their history goes back nine hundred years. The Royal Military Academy at Woolwich was founded in 1741.

At the same time, however, there was much new activity in building canals. In Britain the earliest canals were built with the help of Dutch engineers, but here they found a landscape of rolling hills which was unfamiliar to them. It needed novel engineering solutions – locks, lifts, transporters and tunnels. This was in full swing a generation after General Wade and brought into prominence John Smeaton, the "father of canal building". In 1790 Smeaton and others founded the Society of Civil Engineers. They chose that name to make it clear to the world that they had nothing to do with the military. The original idea was that 'the civils' should represent all branches of non-military engineering but things didn't quite work out like that.

What happened was this: wind and water power had long been used for grinding corn. Now Watt and Trevithick introduced the steam engine as a source of power, first for pumping and operating machinery in spinning and weaving mills, and then for locomotion, and so on to Stephenson and the railway age.

The future for a representative non-military engineering body looked good – except for one little problem. The Civil Engineers thought of themselves as gentlemen, far above the coal-blackened, oily-fingered builders of steam engines. They refused to accept these oily-fingered builders into their Society, and this led to the formation of the Institution of Mechanical Engineers and restricted civil engineering to its modern meaning.

Other European nations do not make such distinctions. They generally have a single engineering body to confer professional status. There, if you choose to become an engineer, you know that when you're qualified, your profession will give you a title which puts you on a par with doctors and lawyers.

A 1775 map of London shows two steam-powered water pumping stations, one described as "An Engine for raising Water by the Power of Fire". There was also an amazing pumping station on a floating base fixed to London Bridge. It had to rise and fall with the tide, and it was powered by a water wheel which used the fall created by water passing through the bridge's narrow arches. Taking a boat under the bridge was like shooting the rapids, and people kept getting drowned.

This is the London Bridge which was "falling down" in the nursery rhyme, and, in the early seventeenth century, it really was. As its piers kept slipping, they had reinforced them from the outside, which narrowed the width available for flow, which increased the scouring action of the water, which made the piers slip some more. Then they decided to lighten the bridge and restore the original width for flow, only to realise that there would be insufficient fall to power the pumps and, if they did that, the City would have no water supply. People just had to keep getting drowned until a new supply from Sadlers Wells was commissioned in 1813.

Not in Britain. Other branches set up their own institutions, such as the IEE and the IChemE, and then a host of others, some with a better claim to professional legitimacy than others. Snobbery and rivalry between the fragmented institutions thrived. And this fragmentation meant that we have never equalled other professions with respect to status (or – which is not entirely a separate matter – income). Engineers remain classed with plumbers and car mechanics.

The greatest Victorian engineers were the Brunels, father and son, whose pioneering ventures include a tunnel under the Thames, the Great Western Railway, and the huge steamships Great Western, Great Britain, and Great Eastern. Few engineers, if any, ever encompassed such a wide range of projects. Most major ventures since then require a variety of specialised disciplines to work together. Engineering consultants began to appear.

I committed a minor traffic offence while driving through darkest Italy, and was stopped by two Carabinieri, who demanded to see my passport. This was the old blue sort that showed your profession, and it said "Engineer". In Italy this means you are a qualified professional engineer and gives you the same sort of status as "Doctor" or "Barrister". They nodded appreciatively, "Ah! Ingeniere! Bravo, bravo!" It would not have happened in England.

Then my wife stuck her head out of the car window and said – show them your date of birth! It happened to be my birthday, and I showed them. At this, they laughed, and asked me round to a nearby trattoria for a drink. As I say, it would not have happened in England.

I graduated in 1950, the first year that London University ever awarded a Chemical Engineering degree (the course had been shambolic). I was looking for a job, and was told not to bother with ICI, then by far the biggest chemical company in Britain, because ICI did not recognise Chemical Engineering as a profession. The Institution of Chemical Engineers (founded 1922) was for long considered a Johnny-come-lately by the 'senior' Institutions. IChemE members, in return, know that they are a superior species – the engineering professions' salary reviews show that they earn more than all the others.

Consultant engineers

Until the Brunels, the most successful engineers were also entrepreneurs, and some became quite rich. But as the projects which followed became bigger and more sophisticated, they were financed more and more by corporations, so these opportunities dwindled. Engineers who couldn't start their own business had to turn to selling their skills by becoming employees – or consultants.

By the end of the nineteenth century engineers had gathered in their own corner of London, like doctors in Harley Street and jewellers in Hatton Garden. Engineering consultants settled around Victoria Street, Westminster, which had only been built a few years earlier in order to give good access to Victoria Station. (The engineer in the Sherlock Holmes mystery "The Adventure of the Engineer's Thumb" took offices there after first qualifying. As I recall, he wasn't very successful.) There are now 3000 doctors in Harley Street, jewellers still thrive in Hatton Garden, but I can't think of any engineering consultants who are still in their old place.

Contractors and consultants have rather similar functions: they are paid by a client to take a part in executing a project. In fact, their skills overlap at many points. Neither of them needs much capital to set up in business because they are both selling skills rather than material things. A contractor supplies material, true, but only stuff which was bought or had been fabricated. The contractor also supplies labour, but again much of it is hired for the specific project. Neither kind of activity needs much fixed capital, and consultants – who sell only their skills – need even less working capital than contractors.

Big industrial companies used to carry staff who would deal with general engineering problems. In their efforts to cut costs, companies have been shedding any who are not expert in the company's own technology. Nowadays, when they consider any project, therefore, they need outside help, and this should mean more specialist consultancy work. Indeed, even big consultants aren't above employing outside specialists to help in areas which are not in their expertise. But unfortunately there are all-too-many examples of projects which didn't get such help, because the client was too stupid or too stingy to pay for it – only to find that that was a false economy.

The name 'consultant' has come to represent two rather different kinds of enterprise:

1. big ones who offer a range of technical and organisational skills
2. small ones, often only one-man affairs, usually with some expertise in a specialised branch.

Big consultants

Looking at the list of stages through which a project goes, you will find that the big consultants can do everything needed from the stage at which the client decides to commission a project. The consultants' duties on a project can include all the following, or only some of them.

- Preparation of tender documents
- Tender evaluation
- Recommendation for contract award
- Site supervision
- Re-measurement (in Civil work) and valuation
- Agreement of extras
- Release of payment to the contractor
- Witness testing of equipment
- Acceptance of completed works.

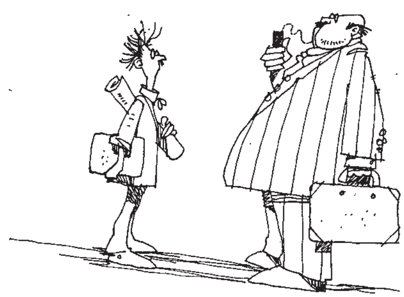


Figure 12 *Big and small consultants*

Typical fees for this kind of work would be 10% of contract value for smaller contracts, falling to 5% for big ones. Or they might charge by the man-hour, at £30–£150/hour (in 2005) depending on the grade – not astronomical sums when compared with the fees commanded by other professions (see below). Consultants working on a percentage of the contract value have a vested interest in seeing the highest capital cost. They will often favour over-engineered designs with higher contract prices.

Originally the big consultants were Civil Engineers, and many of their founders' names (like Binnie, Donkin, Macdonald, Mott and Taylor) survive even after years of mergers and disappearances. These companies can do everything involved in commissioning a project in their field of expertise, drawing up a specification, designing the project, going through the tendering procedure, supervising the actual work and carrying out the acceptance test. Something of the Civil Engineering bias remains even with those who can undertake a sea water desalination plant as easily as a complete airport.

Where the consultant writes the contract they also write the rules of the game. Very sensibly, the consultants protect themselves by passing responsibility for technical problems on to the contractor. The contract might read "notwithstanding the foregoing the contractor shall be responsible for providing a complete and fully operational plant". That is, in plain English, "if we're wrong, it's the contractor's fault". Elsewhere it might say "the contractor's scope of supply shall include but shall not be limited to…" – again, in plain English "if we've forgotten anything, the contractor must pay for it". After years of lawsuits, these tricks no longer offer the consultant much protection, so now they must shoulder the responsibilities, or officially pass them on to the contractor.

If consultants are commissioned by the client to do all these things, the contractor is reduced to the level of a tradesman who just does as they are told. Since no skill is required of them, they will generate none, and the technology remains static.

In the big consultants' heyday this situation was common. The consultants *KNEW*, whereas the contractor didn't, and it bred a certain arrogance in them. Today the contractors often have in-house experts who are equally as good as theirs, and especially in specialised work they tend to be more up-to-date. But the arrogance hasn't quite disappeared – yet.

All this bred a confrontational attitude: some consultants still see contractors as unscrupulous tradesmen who swell their profits by cheating whenever they can, and some contractors see consultants as arrogant spectators who thwart their efforts to make an honest living. They're both wrong.

Traditionally where a big consulting firm was managing a project, they appointed 'The Engineer' (usually a partner) to be in charge, with God-like powers to judge whether to accept work and (more importantly) whether to release a payment for it.

Small consultants

To divide consultants into big and small is of course artificial – there is a size continuum. But there are a very large number of really small ones, many of them one-man outfits. They trade on being specialists in some field, and some may also trade on having the specialist equipment which is essential for it. The technical variety of subjects which all these people cover is huge, ranging from soil mechanics and geophysics through to biotechnology and precision machining.

It is not a route to easy riches. A small consultant sells intellectual property, measured in terms of man-hours. As in a Cost Centre a person can't actually book more than 1500 hours/year to their contract. Out of the gross income they have to pay overheads, which include an office and all that goes with it, a car, and maybe some specialist equipment. A large telephone bill has to be paid, they need help with accountancy, tax, and VAT, etc. Professional Indemnity insurance is mandatory and can cost anything from £1000 to £10,000 a year.

Chapter 13

If the consultant falls ill, income stops, as it does when they go on holiday. If consultants buy a ticket to watch the Test Match, they must add the lost income to the price of the ticket – that's always provided they get enough work to fill their time. However, like contractors, consultants are lucky if they have much in the way of steady work. The enquiries come in at random, with periods of over-work alternating with idle ones.

This end of the consultants' range has a particular problem. Consultants trades on expertise, which means they must have experience. Who is better equipped for that role than some highly experienced and recently retired technologist – he may have retired (prematurely, perhaps) with a good pension. He doesn't need to earn a living any longer, but thinks it would be nice to make a few bob more. So he becomes a consultant. There are many like him, so it's a very competitive market, filled with people who don't really need to charge a lot. It keeps the fees per hour low (and I, as a full time independent consultant, suffer as a result!).

I used to wonder why engineering consultants have to charge much lower hourly rates than, for example, management consultants. The head of one of our most prestigious Schools of Management (who calls us engineers 'plumbers') explained it to me. "The less precise your subject is, the more you can charge," he said. "Your trouble is that you deal with facts and numbers. Nobody pays a lot for that. Management is always in a bit of a fog, so Management consultants can charge more. But the guys who give seminars on really woolly stuff like 'leadership' or 'lateral thinking', they charge £500 an hour and more, and people pay them. Fantasy is worth more than fact".

Another problem is that specialist contractors have the same skills as consultants and may even be more up-to-date. Some of them are quite free with their advice in order to get work. Of course this advice is bound to be biased – at worst it could be like getting a fox to tell you how to build a chicken coop. I'm all for the client listening to people who give this free advice – at least it's likely to be up to date – but always with the thought at the back of their mind that nothing is for free. The advice is being given to them 'free' by the contractor who hopes to land the contract. That's OK, but is the advice sound, or is the contractor's agent just promoting something that only their company can provide?

The contractors themselves will sometimes take on consultancy. We sold some contracts to South Africa on a 'Design and Commission' basis. On those contracts the client bought and constructed everything to our specifications and designs (more cheaply than we could from the UK). When they'd put it up we sent out our commissioning engineers to get it going.

You see how the lines between clients, contractors and consultants become more and more blurred. In fact, this has always been the case in newer industries like computer software. That also applies at the big consultants' end. There are now huge contracting companies who have the necessary in-house expertise for a wide variety of projects. If they haven't got it all, the simple solution is for them to take on specialist consultants to fill the need. Some of these contractors (like Kellogg, Brown and Root, for instance) are true multi-nationals with offices in major cities around the world. The client can turn to such a contractor and award them a 'Turnkey Contract', according to which the contractor does absolutely everything.

The relationship between large contractors and large consultant firms takes various forms. Sometimes the specification and design work remains to be done by a consultant; sometimes it doesn't, even though the contractor may have all the skills needed to do it. Sometimes the consultant's role is limited to checking that the contractor is doing a good job. In cases where an Operating Company has been formed to finance a project, the banks who back the project may insist on such a supervisor, for fear of getting stitched up by the naughty technologists.

One of my court cases was on a project where the contractor had designed everything and the consultant was only supposed to act as a watchdog. In this case, at any rate, it was not very successful. When I asked the consultants' staff why they hadn't intervened in what looked like an obvious breach of the contract, they said their budget was limited to such a small number of man-hours that they couldn't look into that sort of detail. They, the consultants, had been taken on because the bank demanded it, but their duties were almost nominal.

Moral: consultants provide an essential service. They, too, think they are entitled to make an honest living, and they will do as much work as they are paid for. Like the contractors who will build a bad plant if the specification demands it, a consultant will do a poor job if they are not paid properly.

Hence the saying "Pay peanuts, get monkeys". In the days of the Soviet Empire I heard the Russian version of this, which was "They pretend to pay us, and we pretend to work". Unsurprisingly, people are the same everywhere.

Specification

The most important part of the consultant's role is the preparation of a specification. A contractor will just meet the specification, even if it is inadequate. So employing a competent consultant – either an individual or a firm – to ensure that the specification is correct before placing the contract, is generally cheaper than making mistakes. Rates charged by consultants for engineering work are lower than the rates charged by the same consultants for expert witness work in post-contract litigation.

Many purchasers will accept the 'free' advice given by contractors rather than spend money on employing a consultant. And many specialist contractors provide perfectly sound advice, although it is often loaded in favour of some process or construction technology unique to that contractor. There is, of course, no such thing as free advice: the cost of providing it is covered in the contract price.

Some contractors, particularly in the process industries, are also offering their specialist services as consultants whilst many traditional consultants are either forming strategic alliances with contractors or are themselves taking on the role of management contractors. This illustrates how the distinction between the roles of the contractor and consultant are becoming more and more blurred.

Summary

- **Most sizeable projects today call on such a variety of skills that specialists have to be employed**
- **Commissioning a project without having had the benefit of expert advice can be very costly**

- **Specialists who work as consultants should provide unbiased advice. Those who work for contractors will inevitably try to favour their own company's technologies**
- **The boundaries between the roles of consultants and contractors are becoming more and more blurred.**

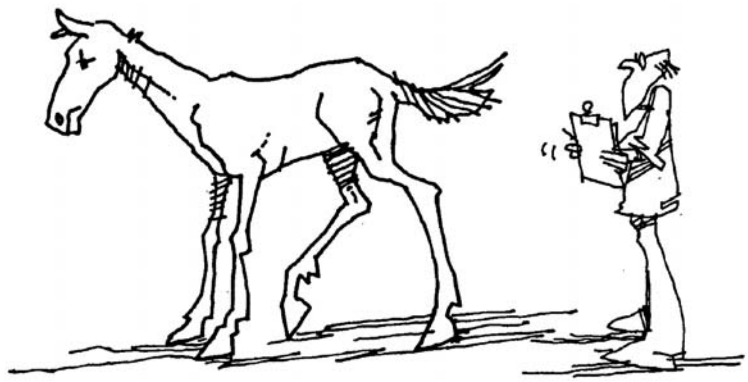


Figure 13 *Taking advice from appropriate sources is important…*

24

AWKWARD ASPECTS OF DESIGNING ANYTHING

Choices

For the engineer, designing anything implies making different kinds of choices. One of these is between different ways of meeting the demand – for example, deciding whether to go for a suspension bridge or a box girder bridge, or perhaps just running the road further inland thus avoiding the need for a big bridge altogether. Another kind of decision arises when there is a range of sizes available – such as, for example, selecting the optimum diameter for a pipeline or for a power transmission cable. Yet another arises when the engineer is not following a clear specification, but has a growing demand to satisfy, and must decide for how long in the future this will last.

If money is a measure of all valuable resources, it follows that good engineering should provide the cheapest answer to whatever is required. The cost which we aim to minimise is the Life Cycle Cost – that is, not only the cost of providing the item which we are designing, but also the cost of operating and maintaining it in the future, and the costs associated with its environmental impact. Operating costs – power, chemicals and other consumables – and the man-hour costs of maintenance are fairly straightforward to calculate, but environmental costs present more of a problem because they are dependent on the boundary within which you are considering them.

For example, we can consider the factory wall as a boundary and consider all the environmental costs associated with operation within the factory walls. However, this does not include the environmental costs of transporting chemicals and other consumables to the factory. If we draw our boundary, say, 50 miles round the factory, we might pick up the fact that the trucks supplying the consumables will cause problems in the local village requiring road widening, pedestrian crossings and so on. You get the idea.

"Electricity is the cleanest form of energy" – true or false? If Los Angeles were to allow only cars powered by rechargeable electric batteries, would that be an environmental benefit? Depends where: Los Angeles would certainly be less polluted, but, all other things being equal, the total power demand would be greater. We would need the power to drive the cars plus the losses in rectifying and charging and losses in the transmission lines from the power station, which is oil fired, so globally the CO_2 emissions will be higher. Let's not forget that the complete car, battery and charger is (at present) more expensive than the petrol alternative which implies that more materials and power have gone into making it, so it has a bigger environmental impact even before it leaves the showroom.

What do these costs mean?

Doing sums to find the lowest cost solution is all very fine, and engineering degree courses often include beautifully designed problems of mathematical optimisation. But in reality it can't be done with any degree of certainty.

As students, we were given an exercise to calculate the optimum thickness of lagging on a steam pipe. It's 50-odd years ago so I can't possibly remember the formula we developed, but the variables which it took into account were: Steam temperature, Lagging conductivity, Pipe diameter, cost of lagging per unit volume, lagging thickness, and cost of heat. We got these into a single expression to give the cost in 20 years, added the capital cost of lagging, equated the differential to zero, and – hey presto! – had the optimum lagging thickness. No one told us that the result would be of no practical use, because lagging comes in standard thicknesses.

The most obvious reason for this is that an important part of the data on which any such decision is going to be based can't be known with any accuracy. The cost of constructing a particular piece of hardware might be accurately known – if you already have an offer from a contractor or supplier, you will know it with total certainty. But the future costs of operation and maintenance cannot be estimated with great confidence – power costs and labour costs will change with the years, just to mention two important ones. And in most pieces of engineering design, the future costs far outweigh the capital expense.

When designing anything there are, actually, a lot of factors which must be considered which cannot be expressed in terms of numbers, or at least not with any realistic degree of accuracy.

Optimisation

In some cases there is a continuously varying factor – such as, for example, when the designer has to choose the best diameter for a power transmission cable. It may be possible to take the factors which influence the life cost and gather them into a mathematical formula, which can be differentiated and equated to zero to find the best solution.

More frequently the computer can be programmed to calculate costs over a great range of alternatives and print out only the option which yields the lowest cost.

You can have no confidence in any exercise which yields such a 'best answer'. Take the case of a calculation which relies on creating a formula, differentiating and equating to zero. The 'optimum' comes at a place on the cost curve where the slope is zero – i.e. it is flat. If the entire curve were printed out, however, it is very likely that it would show the slope on either side of this point remaining slight for a wide range of variables. This means that even the cost of a design which is quite a long way off the 'optimum' may not be significantly different from the 'optimum'.

As we have just seen, the basis of the cost calculation is inevitably inaccurate. If it is to be realistic, therefore, the cost curve should not be a line at all, but a cloud which takes into account the uncertainty of at least some of the data used. What is more, some factors may have not been taken into account at all, most often because they cannot be turned into numbers.

A recent publication estimates that in the life cost of public supply waterworks, the capital cost element accounts for 8%. Power, supervision, chemicals and maintenance account for the other 92% I don't have much confidence in the accuracy of that calculation, either, but then accuracy is not needed here. The qualitative result is clear.

My 6-year old diesel car conked out at 126,000 miles and I got £600 for the old heap. It had cost me about £9000 new and gave me 10 miles/litre of Diesel. I estimate that the fuel it used doing all those miles cost about £10,000, routine service £2000, and insurance and Road Fund Licence another £4000. So the capital cost of a car is also less than its operating cost.

About ten years ago I was shown a major study into the design of a huge sea water distillation facility for Singapore, an island which is understandably nervous at depending for its drinking water on a pipeline from mainland Malaysia. Sure enough, the study selected an 'optimum' design but sensibly printed out the costs for the entire range of options with respect to a main parameter (I forget which). Scanning the list, it showed very little difference between different designs – the difference between the highest and lowest cost was less than 2%. Fuel costs are of course the biggest single item of cost of distillation and the oil price has more than doubled since then. The identical calculation based on today's oil price would probably point to a completely different design as the 'optimum'.

A Common Engineering Example

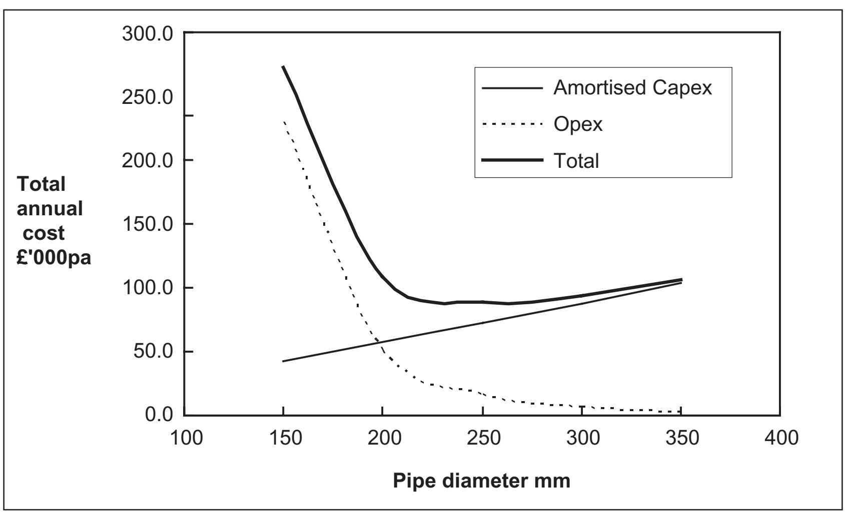
Let's suppose we want to pump 10 Mld (417 m^3/h) of drinking water along 2 km of ductile iron main. A small diameter pipe will be cheaper to install than a large diameter pipe but the velocity, and hence the head loss due to friction, will be higher in a small diameter pipe than in a large one. So as the pipe size increases the capital cost increases but the costs of pumping decreases. So what is the optimum pipe size?

Let's assume that the capital cost of the pipeline is to be amortised over 20 years, that power costs 5p/kWh and that the pipeline will be utilised for 70% of the time.

The capital and operating costs are set out in the table.

Pipe diameter	mm	150	200	250	300	350
Capital cost of pipe per m	£/m	123	168	213	259	306
Installation per m	£/m	296	403	512	622	734
Total capital cost per m	£/m	420	570	725	880	1040
Capex for 2 km	£	839,492	1,140,000	1,450,089	1,760,000	2,080,000
Amortised over 20 years	£'000pa	42.0	57.0	72.5	88.0	104.0
Total head loss over 2 km	M	463.3	103.3	32.3	12.5	5.6
Pump power at 70% efficiency	kW	751	168	52	20	9
Annual consumption	MWh	4608	1028	321	124	56
Annual cost at 5 p/kWh	£'000pa	230.4	51.4	16.1	6.2	2.8
Total annual cost	£'000pa	272.4	108.4	88.6	94.2	106.8

Or we can draw a graph:



Engineering textbooks will tell you that the optimum pipe size is at the minimum of the curve. But the curve here is fairly typical of this sort of calculation in that it has no clear minimum – between 200 and 300 mm the curve is pretty flat. Add to this the fact that the capital cost curve is known whilst the operating cost curve is based on today's price for electricity. If that were to increase the apparent optimum would shift. If you don't expect the power cost to rise, the logical choice is to spend the minimum amount of capital and use a 200 mm pipe.

'Precision' - the Curse of the Computer

> I went on my first computer course in 1957 – early days! The computer occupied the whole top floor of Imperial Chemical House in Millbank (the top floor, in order to facilitate cooling, because it was all thermionic valves). But the people who ran it had divined its character. "We call the computer TOM" they said, "which stands for Thoroughly Obedient Moron".

This is all quite obvious, but nowadays it is compounded by the use of computers, which are simply accurate calculating machines, which is wonderful. Unless you tell them to do otherwise, computers print out all results to seven significant figures, which is nice of them. Most people take that seven-digit number and use it for whatever use they have for it next, which shows that they are idle and foolish. Instead of implying that the number is accurate and reliable, they should look at the basis of the calculation, estimate the intrinsic error, and present the result accordingly.

> Until 30 years ago, such calculations would largely be done on the slide rule – affectionately known as the 'Guessing Stick'. This had two disadvantages – the result couldn't be read to more than three significant figures, and it didn't give you the decimal point – you had to follow the calculation in your head and put that in yourself. Which, in turn, meant that you had to follow the calculation instead of letting the machine do it; and if you had made any mistake in feeding in the information you would probably spot it quite soon. So these 'disadvantages' had their uses.

When designing a car, for example, you might calculate its weight by adding those of all its proposed components. Suppose the total comes to 1351.530 kg, what does that really mean? 1350 kg might be reasonable, implying anything between 1345 and 1355 kg – three significant figures, not seven. If I don't know how accurate the components' weights themselves are (perhaps they too are estimates) I might feel safer with two significant figures, saying that the car, if built, will weigh between 1300 and 1400 kg.

This is not a trivial point. One of the court cases in which I acted as Expert Witness arose from someone assuming that he had been given exact information, when he hadn't. His company went bust.

Chapter 12

Summary

- **When calculating operating costs it's important to define the boundaries around your calculations**
- **Optimisation calculations based on capital and operating costs may be misleading**
- **You need to understand what the numbers mean – "Excessive accuracy shows mathematical immaturity" – J K F Gauss, the great mathematician and physicist.**

25

MORE AWKWARD FACTORS IN ENGINEERING DESIGN

Is it measurable?

The last chapter pointed out that all data are more or less inaccurate. Of course this applies to factors in design which can be presented in terms of numbers, but – worse – there are also factors which are important in design, and which are hard or impossible to measure in terms of numbers at all. As they just make life more difficult, there is therefore a danger that they get ignored.

Few engineers are ever taught that we use numbers for three quite different purposes:

1. Numbers can be used as names e.g. in 'Boeing 747', 'Number 47 Bus'
2. 'Integers' are for counting, e.g. the number of people in a room. They are exact, whole numbers
3. 'Real numbers' are measurements, etc., which are never completely accurate – people have calculated π to billions of places, and still haven't got to the end.

The important thing is to remember that real numbers are never totally exact. There is always some error – however small.

Utilisation

One of the most important factors in estimating the Life Cycle Cost of any item is the proportion of real time during which it is actually going to be in use. This is an absolutely crucial factor which is sometimes ignored completely. It is a useful discipline to make it a rule to calculate operating costs in terms of £/year. You can't do that without supplying the calculation with a number for utilisation.

When designing industrial water treatment plant, there is always a range of designs from which the designer must compromise between capital and operating costs. We were often asked to include in our offer the operating costs (due to the consumption of chemicals) in terms of pence per m^3. That yields a number in which the utilisation plays no part, and which is not much use beyond comparing different contractors' offers for the job.

Presenting the cost in terms of £/year of operation at the expected utilisation would be much better. If nothing else, that would force the client to think about the probable utilisation and specify it, so that the contractors had a base for their sums. The result might indeed be unreliable, but it would give the client a number to compare with the capital cost of the plant. They might then find that the operating cost is relatively small, and that a design low in capital but high in operating cost would be better. Or the reverse might be the case. Pence per m^3 doesn't give you that information.

When equipment is in use, it usually runs up operating costs – by using power, chemicals, etc. Maintenance and supervision costs may also be linked to the actual time it is in use, such as for example the need for a 10,000 mile service on a car. When not in use, on the other hand, it may be costing nothing except the depreciation on its capital value.

Even when a figure for utilisation is given, it is often wrong, which is not surprising because it is often difficult to predict. The utilisation of equipment in industry is generally unexpectedly low: one would think that the major units in an oil refinery which works the year round, would be something like 50 weeks in the year. Actually, records show that typically oil refinery units are in operation for as little as three quarters of the time.

A car's job is to get you from A to B, and the average family car does about 10,000 miles per year. Suppose its average speed overall is as low as 35 mph, that means 286 hours/year or 3.3% of the time – the other 97% of the year it just sits about quietly rusting away. This doesn't of course apply to the Managing Director's Jaguar. Its job includes sitting gleaming in the reserved parking space to prove to the world what an important and powerful person its owner is, so its utilisation is much higher.

In many cases it's not so much difficult as impossible to predict the utilisation. A manufacturing unit might be designed on the basis that it will operate during normal working hours. If it turns out that its product is successful and in great demand, will it then go to weekend working, or two shifts a day, maybe even three shifts a day? How is one to predict its utilisation?

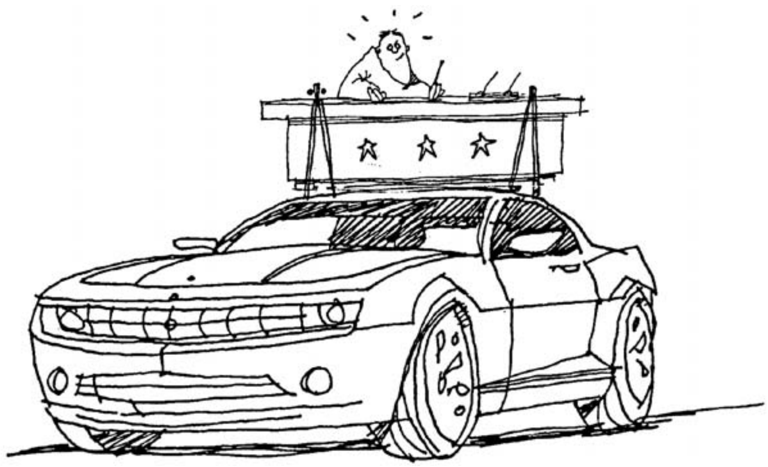


Figure 14 *Managing Director's Jaguar*

Utilisation has a vital effect on the Life Cycle Cost figures – the higher the utilisation, the greater the impact of operating costs in relation to the capital cost. With something which is only in occasional use, on the other hand, the operating cost is much less important. An extreme example: there is no point in buying an expensive efficient motor to drive a pump for a sprinkler fire prevention system. With luck it will never be used except for testing the system, so the annual electricity consumption is just about nil. This is a characteristic of anything which serves as 'insurance' or 'emergency' equipment.

Usually utilisation refers to time, but here's another way of increasing utilisation in order to get more work out of a piece of equipment. Many breweries nowadays brew the beer at up to double the strength at which it is to be casked or bottled, and water it down as the last stage in production.

Utilisation has a direct effect on the engineering design of any piece of equipment. My car gave out after six years, at 126,000 miles, which I thought wasn't bad. A long-distance lorry might do the same distance in a year, so the specification to which the lorry's engine is built is very different. (I'm told they have chromium-plated cylinders.)

Many years ago the Government of Jersey commissioned the building of a sea water desalination plant. The aim was to provide an emergency water supply to save the tomato crop in the event of drought. For twenty years there was no drought. By the end of that time, the plant had corroded into dereliction. It had never operated at all.

Reliability

Car engines have coil ignition. Light aircraft engines traditionally have two independent magneto ignition systems with two sparking plugs per cylinder. Magneto ignition will function even if the battery is flat – a coil ignition won't. In case something does go wrong, a twin system means the chances of the ignition failing are very small indeed. The reason for spending so much more is obvious: failure of a car engine is inconvenient, that of an aircraft engine is rather more serious.

Unfortunately it is more or less impossible to express the need for reliability in numerical terms. And the level of reliability needed can vary a great deal. Any machine will fail sooner or later – it's just a case of when. In any project, the client's specification should give at least some indication of how important reliability is going to be or, better still, specify what installed spare capacity is required.

I once asked a manufacturer of galleys for passenger aircraft what criteria of reliability they used, thinking of the disaster if the crew found in mid-air that they couldn't heat up two hundred frozen airline platters. He said the aircraft makers' spec asked for a minimum period of (I think) 100,000 flying hours between failures, which is probably longer than the lifetime of the plane. So they do have a number to work to, but in practice it is little help. 100,000 hours is over 11 years – you can't realistically test cookers for 11 years on the off chance that one might fail.

It's not only total stoppage which comes into consideration. It could be that the service which the project gives might be allowed to suffer deterioration (of output, or of product quality) for a limited time – sometimes this time is specified; for example, it might be the length of time which it would take to replace the cause of the fault. Or the specified duty is that quality and quantity of the output must be maintained at all times.

When taking off in a light plane the engine should be warmed up by the time you reach the head of the runway. Then, before take-off, you set the throttle at maximum and watch the rev counter as you switch off first one, and then the other ignition system. In fact you expect a slight fall in rpm, because twin sparks give slightly better performance. So in a sense there is a slight falling of output if one system were to fail, but the plane is still safe to fly.

The responsibility for this is squarely with the client or their consultant. The client either has to give a clear idea of the reliability required, or should specify the detail which will ensure it.

There are various degrees of belt-and-braces to ensure continuous performance. Thus the specification can achieve different levels of security in calling for two 100% units (as in aircraft ignition systems), or three 50% units, or two 75% units – and so on. It might be that it calls for items like pumps to have installed standby spares, or that uninstalled spares should be supplied. The specification can either set down general rules of this kind, or go through the individual pieces of equipment one by one.

A specification called for valves on a water purification plant to carry a certificate of mean time between failures. One supplier offered a 'standard plant' – an off-the-shelf product. Although this packaged plant was constructed to normal standards for the industry, and many were installed in similar applications, it had no certificate. The purchaser decided that the specification could not be relaxed and paid four times the price of the packaged plant for a bespoke piece of plant (from the same supplier) which did comply. The plant consisted of duty and standby streams so a valve failure was not really a major disaster. In this case it really is questionable whether the purchaser spent his money wisely.

The important point is that if the purchaser's specification does not lay these rules down, the contractor's designer will choose the cheapest option in order to produce a competitive offer. It may be so close to the limit of what is asked for, that it fails to meet even minor emergencies. This is where I would like to think that some kind of DBFO contract will evolve in future years that would allow designers to avoid the kind of disasters which we often see nowadays.

Chapter 17

Summary

- **Utilisation and reliability are vital to design but often not specified**
- **Reliability, in particular, is hard to specify in terms of numbers**
- **Unless these items (and others like them) are dealt with in the purchaser's enquiry specification, the designer in a conventional competitive tender must choose the skinniest design that will just do the job – often with disastrous results.**

26

HEALTH, SAFETY AND ENVIRONMENTAL ASPECTS OF DESIGN

Engineering and risk

Earlier on I defined a project as something that hasn't been done before. This means that there is always risk of unexpected things going wrong, but risk is balanced against benefit. There are risks that the contract will cost more than the estimate, in which case it might take longer than anticipated for the benefit to be realised. The Channel Tunnel was so much over budget, and the owners had to borrow so much more money, that the annual income from the tunnel is not enough even to pay the interest charges. Even in this sort of extreme example, the risks are measurable in terms of money. But what about the possibility of injuries, or death during construction and operation, or of damage to the environment? Can these really be measured in monetary terms?

Engineering and, particularly construction, is a risk business. Balancing health and safety risk against benefit is a matter of ethics and this book isn't about ethics, but it's worth noting that all the engineering institutions stress that engineers have an ethical responsibility to ensure, as far as is reasonably practicable, that their activities do not create a hazard to the health and safety of workers or to the environment. It's the "as far as is reasonably practicable" that gives us the problem.

Accidents will happen

My enormously long experience tells me that accidents will happen. No matter how careful people are, mistakes are made and injuries or fatalities occur from time to time. Lawyers, however, don't accept mistakes and look for someone to blame or, at any rate, to sue.

Accidents in the construction industry always get media coverage, largely because it operates very much in the public eye. In 2002/2003 the construction industry reported 71 fatal accidents – that was about a third of all industrial fatal accidents – and, given the nature of engineering projects, you could argue that that's not a bad record.

In my 20 years as company director of two companies we had only one serious accident. One of our commissioning engineers was found dead on the floor of the plant house at the foot of a 4' 6" high step ladder. He had obviously climbed the ladder to operate a valve, fallen off, and broken his skull on the concrete floor. There was no sign of carelessness, recklessness, or drunkenness. "Can't understand it," all his colleagues said, "John was always so careful. He'd never climb a ladder while holding a notebook or anything like that". Privately I wondered whether that wasn't the problem. He had no practice at falling, so when he did have his first fall (as sooner or later everyone will) he didn't know how to protect himself, so it was also his last.

Marc Brunel's Rotherhithe tunnel under the Thames took almost twenty years to construct starting in 1825 until 1843. During that time about sixty workmen were killed. There are two surprising things here: firstly that there were relatively so few casualties, in spite of using new and untried tunnelling technology, the presence of hydrogen sulphide gas and a major flood when the tunnel collapsed; and secondly that any records were kept.

The Rotherhithe Tunnel records were so detailed that we know that the first fatality occurred on 12 July 1825 when an old ganger by the name of Painter had been out drinking, after finishing his shift in the Tunnel. On his way home, he climbed the shaft. Due to his drunken state, he lost his balance and fell to the bottom of the 42 ft shaft and was killed. I wonder what a court would make of that today. They would probably find the contractor guilty of negligence in letting anyone work when drunk.

Two years after the Rotherhithe Tunnel was opened, work started on the Bramhope Tunnel on the Leeds-Thirsk railway. The records tell us that around 2000 men were employed over a period of four years and that there were twenty-four fatalities. That's 300 fatalities per 100,000 man-years. In 2005 the TUC reported 2800 fatalities in the construction industry in the previous 25 years, that's an average of just over 100 per annum. With an average of about a million employees over that time, that represents an average of 10 fatalities per 100,000 man-years, so the industry's safety track record is improving.

Safety law

A lot of the risks in engineering projects are contractual risks – budget, programme, damages and so on – and these are subject to Civil Law, which covers disputes between parties. Health and safety issues are different: they are subject to Criminal Law: if you don't comply with Health and Safety legislation you are committing a crime and could be prosecuted. If there is a fatality involved you could be prosecuted for manslaughter. In addition, you could be sued for negligence and/or breach of contract under Civil Law.

A company director received a suspended prison sentence following his conviction for manslaughter as a result of a fatal accident at a factory in Lancashire in 1988. In that case the accused was shown to have had direct responsibility for the accident. More commonly it is impossible to establish in law that directors are personally responsible, even if their direction has led to unsafe practices or poor maintenance. Following the Herald of Free Enterprise shipwreck and several train crashes, there is now a move to introduce a 'corporate manslaughter' law.

The most important legislation in English Law is the Health and Safety at Work Act 1974, which covers all aspects of health and safety in every kind of working environment from construction sites to shops and from garage workshops to agriculture. In plain words, the Act states that an employer has a statutory duty to care for the health, safety and welfare of employees and any other people who may be affected by their activities (for example, the employees of contractors or members of the public). The Act also set up the Health and Safety Executive to implement the legislation. The Health and Safety at Work Act made the contractor responsible for safety on construction sites.

In 1994 the European Construction Industry Directive came into force and is implemented in English Law as the Construction (Design & Management) Regulations (CDM). These regulations place a legal obligation on everyone involved in the construction process to provide for site safety at every stage of a project. The contractor no longer has sole responsibility but Clients and other construction professionals such as designers, consulting engineers, project managers, surveyors, architects and landscape architects all share in that responsibility.

This is not the place to discuss in detail the CDM Regulations but, briefly, they work like this. At the beginning of a project the Client has to appoint an individual called the 'Planning Supervisor' who prepares a Health and Safety Plan which forms part of the tendering process. Before construction work begins, the plan is passed from the Planning Supervisor to the Principal contractor who revises it to meet the site activities and the contractors involved. The Client has to ensure that a plan has been prepared before construction begins and the Principal contractor has to hand it to the Client on completion of the contract.

On Wednesday 23 May 1984, a group of 44 people was taken on a tour of a water pumping station at Abbeystead. While in the valve house an explosion occurred in which 16 people died. The explosion was caused by the ignition of accumulated methane. On the evidence that there was a risk of methane being present which should have been taken into account in the design, the designers (Binnie & Ptrs, consulting engineers) were held liable while, on appeal, the contractor (Nuttalls) and the operator (North West Water) were held not liable.

The Designer (whether an individual or organisation) is obliged to:

- ensure so far as is reasonably practicable that the design avoids foreseeable risks to persons who do construction or cleaning work;
- ensure so far as is reasonably practicable that the design includes adequate information about structure or materials which might affect health and safety;
- co-operate with the Planning Supervisor.

So the designer has a major responsibility for safety during the construction phase of the project as well as in future operation.

The trouble with all this is that the qualification 'reasonably practical' represents reality and is, of course, wonderfully vague.

There has been a steady decline in fatalities in the construction industry from 5.7 per 100,000 workers in 1992/2002 to 4 per 100,000 in 2002/2003, but whether the CDM Regulations are entirely responsible is questionable.

One evening, doing an unofficial experiment of his own, one of my research assistants used a pipette to transfer some acetone (he should have known better) and got some into his throat. The following morning he complained of a sore throat, visited first Aid who, on hearing the story, reported it to HSE. I was threatened with prosecution. Never mind that it was outside working hours, an unofficial experiment, or that he had a BSc and MSc in chemistry: I was responsible. Eventually they relented, but where was 'reasonably practical' then?

Risk assessment

We frequently hear that human life is infinitely precious. This is true for the individual and their nearest and dearest, but can hardly be considered true for society as a whole. In fact there are various examples in which the value of a human life must have a number attached to it. For example, how much does the designer of an ocean liner spend on lifeboats and other rescue equipment? Who decides on that figure, and how do they arrive at it?

If we are going to place a cash value on life then, logically, that cost should be the loss that we would incur if we were to be held responsible by a court for the death. This is likely to be the sum paid out by insurance companies on accidental death (typically about £100,000).

Risk to the environment is just as difficult to quantify. Costs resulting from environmental damage during construction would be the responsibility of the purchaser and are likely to be passed on to the contractor under consequential loss. The loss of amenity value and income in a trout fishery destroyed by chemicals can be reasonably estimated, as can the cost of cleaning it up and re-stocking it at the polluter's expense. On the other hand, an established tree felled by mistake cannot be reinstated, a rare orchid destroyed by a bulldozer cannot be replanted and a listed building demolished in error cannot be rebuilt exactly as it was. The environmental costs are unquantifiable and, in any case, a matter of opinion. Some people are passionate about orchids whilst others are completely unmoved. Nevertheless, the world is shocked by environmental disasters of the magnitude of the Torrey Canyon or the Esso Valdez oil spills.

> Three Valleys Water constructed a filtration plant at their Clay Lane site in Watford. The site is rather special as it is home to both Greater Crested and Smooth newts and the contract required that the contractor ensured that no harm came to the newts. All site staff had to be instructed on how to handle the newts, and any that strayed into the construction area had to be relocated to the adjacent Environmental Centre.

The purchaser may well recognise the legal and moral needs of health, safety and environmental aspects of the project but will not unreasonably ask "How much will it cost?" If the safety input is timed correctly the cost can be minimal. Indeed, taking account of health and safety during design can avoid costly problems later and actually reduce project costs in both construction and maintenance. Safety is usually only expensive if it is introduced at too late a stage. If managed correctly safety can be inexpensive and cost effective. Quite apart from the costs and penalties of being taken to law, accidents result in delay, and lead to large costs on that account alone. Good safety can be a sound investment if carried out as an integral part of the project.

A bigger concern is competitive tendering. The contractor may see the need for safety in the design but will be wary of the cost. "What if my competitor doesn't include the same level of safety?" the contractor will say, "The price will be lower than mine and I'll lose the contract". The thrust of the European Construction Industry Directive is to make all parties, including, most importantly, the purchaser, aware of health, safety and environmental aspects. This means that safety should be fully covered in the specification so that, provided all the tenderers comply with the specification, the playing field should be level.

Summary

- **Project engineering and, in particular, the construction industry is relatively dangerous because it deals with the unknown**
- **To meet this danger, there has been a progressive tightening of legislation so that, if a fatal accident occurs today, just about every party involved in the project is potentially liable**
- **The law prescribes certain protocols which should ensure that any foreseeable risk is mitigated 'as far as is reasonably practical'**
- **The $64,000 question is: What is 'reasonably practical'?**

27

RESEARCH AND DEVELOPMENT

What's the difference?

If scientists and technologists had more say in running the world, it would not have become normal to clap these two activities together. Actually they are fundamentally different:

- research is about knowledge
- development is about money.

Clearly, therefore, a book about money must discuss development. That includes a great many things which we call research, but (on the above definition) aren't. When engineers engage in 'research', it is usually aimed at improving our understanding of something which has a practical application – that is to say, it too is ultimately about money.

> After one of his public lectures and demonstrations about electricity, Michael Faraday (1791–1867) was asked by a lady "But, Mr Faraday, what use is it?" He answered "What use, madam, is a new-born baby?" Of course the great man was right, even if the lady, and most of the world since her, let themselves be misled by his reply. The fact is that a new-born baby is no use whatsoever. Making babies is an inexpensive and (usually) pleasurable activity. Turning the baby into a useful citizen, by contrast, takes many years of tedious and costly toil. Faraday could not have found a better way of explaining the difference between research and development.

The challenge of R&D

Young people who are choosing their career and thinking of taking up research should be clear about its true nature. It's not the romantic trade which it is cracked up to be: it rarely ends up with new and exciting discoveries. Most R&D is about failure. The thousands of doctorates which are published annually around the world are mostly tricked out to represent success, but a great number hide one or more of these facts:

> "For me it is all about the challenge. The more difficult the task, the greater the challenge. This is why I have always failed where others have succeeded".
>
> Peter Sellers as Superintendent Jacques Clouseau in *The Pink Panther.*

- we reached no sensible conclusion
- it's become clear that we set out to answer un-answerable or pointless questions
- the experiments didn't work because…. (name any of dozens of reasons)
- we ran out of time.

This seems to make R&D an unattractive trade. It isn't really, but it needs workers who are both determined and resilient – without those qualities it is too easy to get discouraged. Quitters should do something more suited to them, like selling office furniture.

That, in turn, explains why the most difficult thing in an R&D programme is to recognise when you've reached a point at which it is useless to go on. That's particularly so because R&D workers aren't quitters, so they find it hard to stop and cut their losses. (In all these respects R&D resembles mountaineering, and that isn't everyone's cup of tea either.)

> This is my experience after 45-odd years in industrial R & D and supervising postgraduates doing research and writing it up for their theses (and 30-odd years climbing the highest peaks in the Alps).

How do we decide that some R&D project is worth the money which it will cost to carry through? For decision-making in engineering design NPV or payback will give us some reasonable guidelines. These calculations ensure that, in betting terms, we only back odds-on favourites. With R&D the chances of success are much smaller, but we hope the rewards will be much greater. In betting terms, therefore, financing R&D means backing outsiders. That, as anybody who bets knows, is a triumph of hope over expectation. It does, of course, need sound judgment and a good nose for opportunities but, in the end, quite a lot of it comes down to faith.

Appendix 3

Backing the right runner

To treat R&D decisions in terms of gambling is quite reasonable. A very large company (let's say one of the great international pharmaceutical manufacturers) can have so many R&D projects running simultaneously that at least one of them should succeed. That one will make enough to pay for all the others' failures. It's like the bookmakers, who can hardly lose provided they have covered their books.

Since it is difficult to justify R&D in accountants' terms, it's not surprising that when business is bad and something has to be cut, accountants will normally point to R&D as the first victim. This is very wrong. For R&D to succeed, it needs the security of a long-term budget. I am sorry to say that I have only ever met one company which had a ring-fenced R&D budget for a rolling five years ahead, and they were French. And their R&D was rather successful.

Insurance is another branch of the gambling industry. By insuring your house against fire, for example, the insurance company is betting you that your house won't burn down this year. Like bookmakers, the insurance companies hedge their bets, which means that they can't lose – but in the long-term you always will. Insurance only makes sense for people or organisations that haven't got the means to survive the cost of some potential disaster, like their house burning down. Large organisations like the big airlines don't take out insurance: they are big enough to cover the cost of any foreseeable disaster without going bust.

In the 1980s Margaret Thatcher, whose economics worked well in theory but rather failed in practice, convinced a lot of UK businesses that 'downsizing' to give a 'lean and mean' organisation would lead to bigger profits. In particular she suggested that R&D was wasteful and that we could simply license new technology as we needed it from other countries. It worked well in the short-term and most of the UK's R&D facilities were closed. The result is that we now pay large sums in licence fees but, alas, make low profits.

This is slightly ironic as she was an Oxford graduate in chemistry herself and worked in this area before she went into politics.

A cheaper way

A small to medium sized enterprise (SME) may well generate excellent ideas for development, but may not be big enough to finance R&D on a sensible scale. Most SMEs are restricted to carrying out experimental work on actual contracts, sometimes with the client's consent and even financial support. The work that can be done in this way is pretty restricted and usually consist of "stretching the envelope" by tweaking some parameters within a known technology.

One way of saving money is to get the work done in a university. They can make it a PhD student's research project and try to get a government research grant for it. It often helps to get the grant if the company contributes towards the cost. The grants are dished out by the appropriate Research Councils, and they depend on 'Peer Review' (that is, the opinion of academics working in similar lines of technology) to decide whether the project is worth whatever it is going to cost.

In the 1990s a bunch of academic engineers at the University of Cambridge published a peer-reviewed paper demonstrating that it was aerodynamically impossible for the bumble bee (*Bombus terrestris*) to fly. So far this does not seem to have worried the bumble bee.

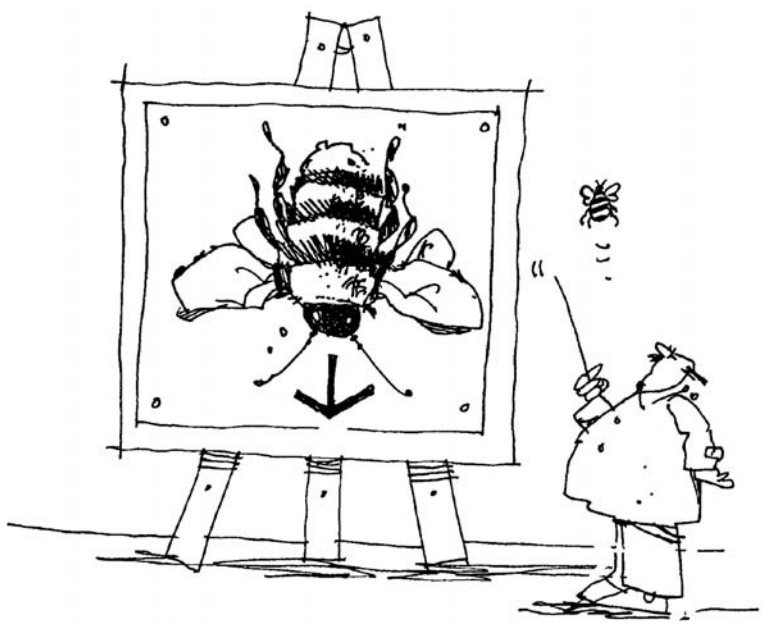


Figure 15 *You can't be flying, … erm … er …*

In practice, this means that the company must find a Professor who is skilled at making a case for research, and has enough chums in other universities to give it the nod. You can, of course, commission a university department to carry out your research on normal commercial lines, without their getting a student to do it for a higher degree. However, that has little advantage, as it would cost about as much as farming it out to a commercial research company would.

Commissioning R&D work as a student's project means that the prime objective of the exercise is no longer for commercial usefulness, but to help get the research worker a PhD. This puts some constraints on the work – especially with respect to time, as experimental work has to stop quite early to allow enough time for writing up the thesis.

I often hear complaints that university work tends to stray into areas which are of no interest to the company who sponsored it. This is bound to happen if the sponsor doesn't stay in close contact with the work. My experience is that universities fall over themselves trying to be commercially useful, but without regular guidance from the sponsor as the work goes on, they can't judge what is really wanted.

Sponsoring work at a university has an important advantage for smaller companies – it provides a link with a wide range of technological skills. My experience is that universities, who are, after all, under some obligation to the sponsor, are happy to provide information free of charge even if it has nothing to do with the project itself.

There are other ways of getting grants. For example, one good source nowadays is to get into partnership with a company in some other EU country: Brussels is keen to promote such international schemes and pays handsomely towards the costs.

One drawback to commissioning work to be done by a PhD student is that it must eventually be published, and therefore any patent application must pre-date the publication of the thesis. There are sometimes ways of delaying publication, especially when the work is of military importance.

The question of patenting will come up if the work promises a useful result. It raises problems which are outside the scope of this book, and they are difficult problems because full patent cover costs a lot of money. It is worth getting a good patent agent to help with them.

Summary

- **R&D is a gamble, usually with long odds**
- **The most difficult thing is to recognise the point when an R&D project is failing and should be stopped**
- **Sponsoring R&D by postgraduates working for a higher degree is cheap, but it's only useful if the sponsor stays in close contact with the work.**

28

SOME FINAL WORDS

That's it.

I hope you now have a better idea of the environment in which you work. MBA courses don't feature most of this stuff. If you want to know more you will have to study in the University of Life – which is, after all, the traditional way of learning the subject.

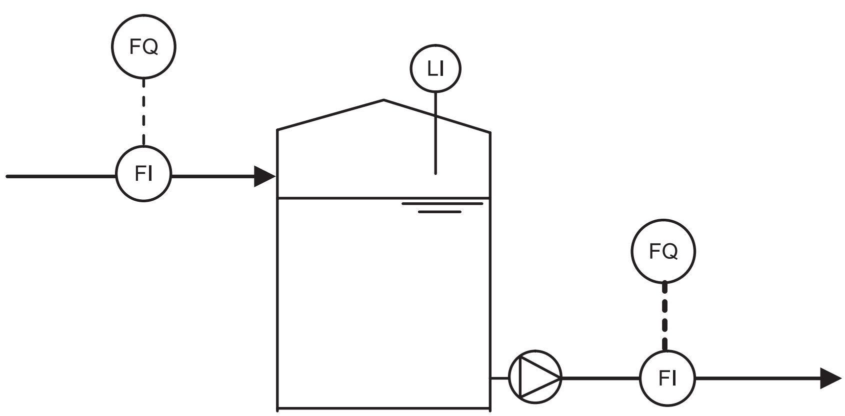
Summary

- **Good luck!**

APPENDIX 1 – FINANCIAL ACCOUNTS

Accounting is all about measuring money. It's important to know enough about accounting to understand what the Accountant is telling you, because it will influence the business decisions that you make as a Project Manager, contract manager or Managing Director. Accountants talk about 'liquidity' and 'liquid assets' so I want to continue the fluids analogy for a bit, because it's an easy one for engineers to understand. Think of the company as a balancing tank for water. Water flows into the tank rather like cash flows into the company – not necessarily at a constant rate (though that would be nice!) nor even continuously. The water flowing out of the tank is also usually intermittent but can be controlled to some extent. The things we can measure are: the volume of the tank contents, the instantaneous flow rates both in and out and the cumulative flows over a period. Hang on to that picture.

Chapter 9



British law demands that at the end of every financial year the company has to submit audited financial accounts (that means they have to be approved by an independent qualified accountant) for public record. For this the company has to provide two accounts: the Balance Sheet and the Profit and Loss account. These are in a standard format so that all companies' accounts essentially look the same and use the same terminology, so we need to understand what they are and what they mean. Published accounts normally show the previous year's figures side by side with the current year's so that comparisons can be made quite easily.

Balance Sheet

Back to the analogy.

The Balance Sheet shows the tank contents on the last day of the financial year. It is calculated by adding up all of the company's assets and subtracting all its liabilities. What's left is the 'capital and reserves' and it's the value of what the shareholders own. The water in the tank is the company's assets. If the level in the tank falls too low, and no more can be found to top it up, then the company doesn't have enough assets to cover its liabilities. It becomes 'insolvent' and may be forced go into 'liquidation'. Chapter 8

Although the Balance Sheet is a fairly daunting document at first sight, it's actually not difficult to understand. A breakdown is given on the next page.

BALANCE SHEET

		2006		2005	
		£'000	£'000	£'000	£'000
FIXED ASSETS					
Tangible assets		3712		4055	
		19		19	
	(A)		3731		4074
CURRENT ASSETS		3044		2523	
Stocks		3544		3170	
Debtors		585		2034	
cash	(B)	7173		7727	
CURRENT LIABILITIES		1147		1826	
Bank loans and overdrafts		2807		3184	
Trade and other creditors	(C)	3954		5010	
	(D = B – C)		3219		2717
NET CURRENT ASSETS					
			6950		6791
TOTAL ASSETS LESS CURRENT LIABILITIES (E = A + D)					
CREDITORS					
Amounts falling due after more than one year	(F)		624		624
Provisions for liabilities and charges			245		217
	(G = E – D)		6081		5950
CAPITAL AND RESERVES					
Called up share capital			1183		1183
Share Premium			95		95
Retained profit (*from P & L*)			4803		4672
			6081		5950

'Fixed assets' are things which the company owns but which are not associated with the day to day business. Fixed assets includes tangible items like buildings, cars, earth moving plants and so on and intangible items like shares in Operating Companies or intellectual property like patents and licenses. 'Current assets' are directly related to the day to day operation. In manufacturing and retailing the principal element usually refers to stocks which means items that have been purchased either for use in manufacturing or for sale. In the case of the corner shop it's newspapers, magazines, cigarettes, chocolate, and so on which you hope to sell. In a contracting company, it means 'work in progress'; that is, equipment and materials such as pumps, tanks, control software, building materials and services like 'outsourced' engineering designs, which have been purchased as part of a contract. Debtors are those who owe money to the company and, in the contracting business, this usually means the contract purchaser. Cash means money that is held in the bank – ideally on deposit earning interest!

Chapter 6

'Current liabilities', like current assets, are associated with day to day business and include any money which has been borrowed to pay for stocks and any money which the company owes to creditors; for example, suppliers, subcontractors, employees and taxes. 'Long term liabilities' such as money which is the company must repay at some time in the future – typically after one year – are usually identified separately and include creditors such as long term bank loans, provisions (allowances for things which have been identified as likely to go wrong, such as a contract which may need remedial work, or a customer who may go bust before the company is paid - a 'bad debt'), and money that is owed to the shareholders.

The value G in the Balance Sheet example must be equal to all the money which the shareholders have invested in the company. It is therefore the same amount as the Capital and Reserves which we talked about earlier. Auditors always manage to get these totals to be the same, which is absolutely bogus because many of the figures which make up items A, B and C contain a lot of guesswork. By and large the Capital and Reserves is a calculating convenience and of little practical importance.

Chapter 5

Depreciation

When we buy materials for a contract, the value of stocks (work in progress) increases, and the value of cash assets goes down to balance this. If we buy equipment (like JCBs or vans) which will be used on many different contracts and will, we hope, last for several years, then these items are regarded as 'fixed tangible assets'. When we buy them, the value of fixed assets increases and the balance is maintained by decreasing the value of the cash assets. However, if the equipment is going to last for, say, ten years, then putting the whole value of the asset onto the first year's Balance Sheet gives a distorted picture. In addition, the equipment will wear out so, after ten years, it will not be worth as much as it was when it was purchased. If you own a car you will be familiar with this. To get round this problem we show the value of the asset at its depreciated value. This is usually calculated using a straight line depreciation method. The annual depreciation is calculated by subtracting the residual value (what we expect to able to sell the equipment for when we have finished with it) divided by the expected period for which we will own it.

> Suppose we buy a car for £12,000 and expect to sell it after three years for £6000; the annual depreciation is (£12000 – £6000)/3 = £2000 per annum. In the first year the asset value would appear as £12,000, in the second year it would be £10,000, in the third £8,000 and in the fourth it would be sold for £6,000 to become a cash asset.

In practice, equipment usually loses more value in the first year and depreciation is not truly linear. Accountants have various conventions for this but the principle is exactly the same.

Profit and Loss

The second document is the Profit and Loss account (or 'trading account'), which gives the cumulative flows into and out of the tank over the twelve months of the financial year. The flow into the tank is the company's Turnover, that's the total amount of money that has been invoiced during the year. A contractor's Profit & Loss account might also show other sources of income – for example, income from shares in a consortium or Joint Venture or fees from technology licenses – but these would normally be small.

Flows out are represented by the Cost of Sales – that's the direct costs of executing contracts such as materials, subcontracts, labour, engineering and project management – and by the Net Operating Expenses or indirect costs or overheads.

Chapter 8

The Profit and Loss account takes the Turnover and subtracts the Cost of Sales to give a figure which accountants call the Gross Profit, to which each contract the company undertakes has made a 'contribution'. Subtracting the Net Operating Expenses from the Gross Profit leaves the net Profit, and this is the amount of money on which the company has to pay tax. After tax has been paid it's up to the directors to decide what to do with the surplus. If the net Profit figure is negative then the company has made a Loss for the year. That isn't necessarily a problem provided that there is still a reasonable amount of water in the tank.

The Profit and Loss account is set out below:

PROFIT AND LOSS ACCOUNT

	2005 £'000	2006 £'000
TURNOVER	25658	25323
Cost of Sales	–18967	–18582
GROSS PROFIT	6691	6741
Net Operating Expenses	–5624	–5223
OPERATING PROFIT/(LOSS)	1067	1518
Interest receivable	100	76
Interest payable	–242	–314
PROFIT /(LOSS) BEFORE TAXATION	925	1280
TAX ON PROFIT	–370	–416
PROFIT/(LOSS) AFTER TAXATION	555	864
Dividends	–424	–431
	131	433
Retained profit brought forward	4672	4239
Retained profit carried forward	4803	4672

(instead of using a minus sign some accounts put negative figures in parentheses)

Assuming that the company makes a net Profit, the Directors have to decide how much of it (if any) to distribute to the shareholders as Dividend. And how much to re-invest in the company.

Chapter 5

So we've looked at the tank contents and the cumulative flows over the year that have produced it. The Balance Sheet and Profit and Loss account conventionally show last year's results so that we can compare them. If the in-flow over the year has been more than the out-flow the contents will have increased and *vice versa*. But remember that the Balance Sheet is a strobe flash of the company at an arbitrary moment in time, while the Profit and Loss account is a summary of the company's operations over a twelve month period. The audit thus gives us a two-dimensional view of the company. Just as in engineering drawings, we all know that two views aren't enough: a third dimension is needed for a really definitive picture. In the case of accountancy that third dimension is Time, so we need to see some years' worth of audits to get it.

> The share price can be a very important factor in creating confidence in a company, and can be manipulated by 'creative accountancy', as Enron found just before its collapse. This is outside the scope of this book. If I knew how to do it I'd have made my millions and retired – or be in prison!

Important though these measurements are, they don't tell us anything about the situation on a day-to-day basis. The cumulative flows might be enough to produce a profit at the end of the year but if the tank becomes empty then there will be problems. If, on the other hand, the tank looks like overflowing it suggests that the company has working capital that is being under-utilised and should be earning income. We need to look at the instantaneous flows in and out of the tank to see if the level is going up or down and whether it's getting near to the bottom or about to overflow. This is what Management Accounts do.

Chapter 3

APPENDIX 2 – CRITICAL PATH ANALYSIS

What's a Critical Path?

Any and every project is made up of a number of activities, some of which depend on others being completed before they can start. We saw how, when building a house, the foundations have to be finished before the walls can be started and the roof can't be put on until the walls are up, but digging the soakaway can be done at any time.

Chapter 20

The Critical Path is that sequence of interdependent activities which together determine the duration of the project. Activities on the Critical Path do not have any time between completing one activity and starting the next. Identifying that Critical Path determines the length of the project, and each activity on it must be completed in the allocated period of time otherwise the whole project will over-run. Activities which are not on the critical path can over-run within a period of time, called the 'float', which does not affect any critical activity.

Critical Path Analysis (CPA) is one of a number of tools – all now available as software packages – that have been developed to allow the project manager to calculate the time required for completion of the project, and to see which are the critical activities.

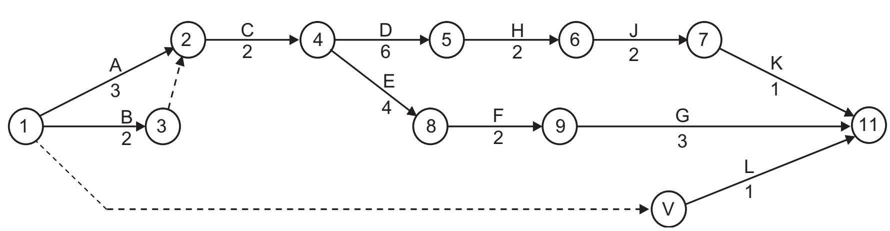
Activity list

The first step in CPA is to prepare a list of all the activities that make up the project and, for each, identify the duration and dependent activities; that is, activities which have to be completed before another can start. Let's use the house building example:

ACTIVITY	DESCRIPTION	DURATION WEEKS	DEPENDENT ACTIVITIES
A	Access road	3	
B	Footings	2	
C	Foundations	2	A, B
D	External walls	6	C
E	Internal walls (lower)	4	C
F	floors	2	E
G	Internal walls (upper)	3	F
H	Roof trusses	2	D
J	Roof tiles	2	H
K	Gutters/drain pipes	1	J
L	Soakaway	1	

Network diagram

We can now draw a network of arrows and nodes – the so-called 'Activity on Arrow' diagram, in which the arrows represent the activities (each identified and with the duration marked on it) and the nodes (sometimes called 'events') are the start or completion of an activity. This shows how the activities depend on one another. The dotted line connecting node 3 to node 2 is a 'dummy activity'. This shows dependence and means that activity C cannot start until activities A and B have both been completed. Dummy activities have no duration.



We can now assign to each activity an earliest start time (EST) by looking at the longest activity path that precedes it. That will take us to the earliest time at which we can reach Node 10, which is completion of the project (in this case 16 weeks). So:

EST for activity C = EST for activity A + duration of activity A = 0 + 3 = 3
EST for activity D = EST for activity C + duration of activity C = 3 + 2 = 5
EST for activity E = EST for activity C + duration of activity C = 3 + 2 = 5
EST for activity F = EST for activity E + duration of activity E = 5 + 4 = 9
EST for activity G = EST for activity F + duration of activity F = 9 + 2 = 11 and so on.

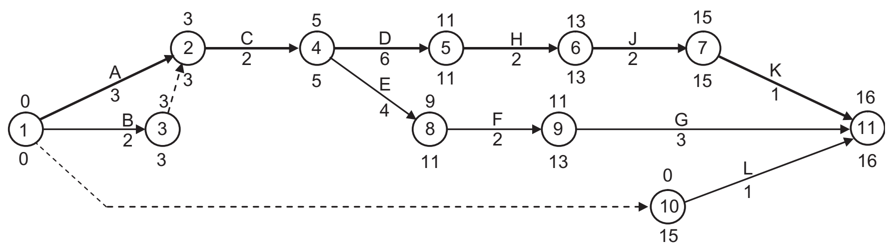
Doing the same thing in reverse, starting at Node 10 and working backwards, gives us the latest start time (LST) for each activity. So:

LST for activity G = 16 − duration of activity G = 16 − 3 = 13
LST for activity F = LST for activity G − duration of activity F = 13 − 2 = 11
LST for activity E = LST for activity F − duration of activity E = 11 − 4 = 7 and so on.

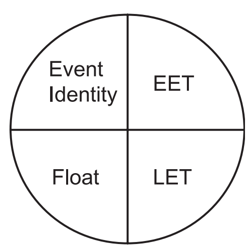
The difference between the latest start time and the earliest start time for each activity is the float. The path with zero float is the Critical Path.

ACTIVITY	DURATION	EST	LST	FLOAT
A	3	0	0	0
B	2	0	1	1
C	2	3	3	0
D	6	5	5	0
E	4	5	7	2
F	2	9	11	2
G	3	11	13	2
H	2	11	11	0
J	2	13	13	0
K	1	15	15	0
L	1	0	15	15

We can now mark on each node the earliest start time and latest start time for the following activity and also highlight the Critical Path:



The numbers above the nodes are called the earliest event times (EET) and represent the earliest starting time for the start of the next activity. The numbers below are the latest event time (LET) and represent the latest possible start time for the next activity that will achieve the project time, which is the sum of the times on the critical path and is shown on the last node. The nodes on the critical path always have the same earliest event time (EET) and latest event time (LET). It is usual practice to include this information in the node like this:



Note that this is only one approach (and the simplest) to setting out Critical Path Analysis and there are several different ways of presenting the network diagram and of annotating it with durations, times and float. In some versions, called either 'Activity on Node' diagrams or 'Precedence' diagrams, the nodes represent activities and the arrows or lines represent the relationships of activities and their precedence. The convention in this system is to use a rectangular node like this:

EST	LST
ACTIVITY DESCRIPTION	
DURATION	FLOAT

APPENDIX 3 – PROJECT EVALUATION TECHNIQUES

To be or not to be …

We are now going to look at the way the client for a project might first decide whether it is sensible to go ahead with it – that is, whether the prospective benefit is worth spending a lot of money on research and development, conceptual design and, eventually, construction. The hope is that the project will bring in an income which is usually measured in terms of money, and that this will more than cover the costs and so provide a profit. The income might be from sales of a product – perhaps a pharmaceutical, a semiconductor device or a petrochemical – or from rent on a building or tolls from a bridge. The same logic applies no matter what the undertaking. How does anyone determine whether it's worth making the investment?

Chapter 3

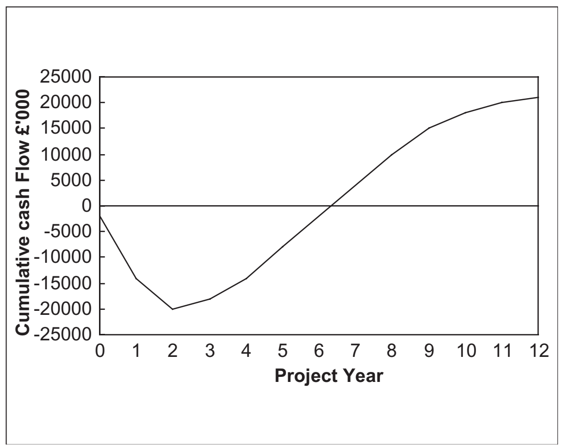
Project cash flow

Let's consider a hypothetical project to manufacture a new plastic. The R&D department reckon that it will take a year to develop the synthesis route in the laboratory and carry out pilot scale trials to make sure that the manufacturing process will work, and that that will cost about £2m. Engineering have talked to contractors and estimate that the cost of constructing a full scale manufacturing plant will be about £18m over two years – £12m in the first year and £6m in the second. The Marketing department are optimistic about the new product and reckon that they will be able to sell £2m worth in the first year, double this in the second year and then sell £6m a year for the next four years. After this, competitive products will come onto the market so sales will probably fall to nothing over the next four years.

Over the twelve year anticipated life of the project the costs will be £20m and the total income £41m giving a gross profit of £21m which represents a return on investment of 21/20 = 105% over twelve years or 8.8% pa. Or does it?

The table and graph show the cumulative cash flow for the project.

Year	income	cumulative
	£'000	£'000
0–	2000	–2000
1–	12000	–14000
2–	6000	–20000
3	2000	–18000
4	4000	–14000
5	6000	–8000
6	6000	–2000
7	6000	4000
8	6000	10000
9	5000	15000
10	3000	18000
11	2000	20000
12	1000	21000
Total	41000	



Let's look at some other methods of project evaluation.

Payback

If a capital sum £*P* is invested in a project which brings in an income (or effects a saving) of £*X* per annum then the 'payback period' of the project is *P*/*X* years. In the $(X + 1)$th year the project starts making a profit.

In our project the payback period, when the cumulative cash flow curve crosses the *x* axis, is about 6.5 years.

It's actually a bit more complicated than that, because if a company borrows a capital sum £*P* at an interest rate of *i* and repays it after *T* years, the total cost is:

$$P_T = P(1 + i)^T$$

So a sum of £20m borrowed at 5.5% pa interest would result in a debt due after 6.5 years of:

$$2 \times 1.055^{6.5} = £28.3\text{m}$$

This increases the payback time which, in turn, increases the cost because of the additional interest incurred.

Amortisation

Amortisation means converting a capital debt into annual repayments. If a company borrows a capital sum £P over a period of T years then, as a first approximation, we can assume that the debt is paid off linearly with time, so that the rate of amortisation is:

$$S \approx P/T$$

If we borrow £20m and pay it back over 6.5 years then the annual payments is:

$$S \approx 20/6.5 = £3.08\,\text{m } \textit{per annum}$$

In fact, we have to pay interest on the money – remember we said that if we use our own money then it's still costing us interest which is the interest we would have earned from it if we hadn't spent it. If the company borrows the money at an interest rate of i and repays it over T years, the annual cost is:

$$S = \frac{iP}{1 - (1 + i)^{-T}}$$

so our £20m at 5.5% interest over 6.5 years would cost:

$$0.055 \times 20/(1 - 1.055^{-6.5}) = £3.74\,\text{m per annum}$$

Converting capital cost into an annual cost allows us to build up a total annual cost which is useful for comparing different options. But it doesn't take any account of how the value of money changes with time.

Time value of money

The value of a sum of money £P at some time T years in the future at an interest rate of i is given by:

$$P_T = P(1+i)^T$$

So the Present Value of £P_T in T years time is:

$$P = P_T(1+i)^{-T}$$

If we look at our steady income of £6m pa over four years and assume a rate of 5.5%, by today's standard it's not worth the £24m we originally assumed; it's only worth £21.03m as the table below shows:

Year	PV £m
1	5.69
2	5.39
3	5.11
4	4.84
TOTAL	21.03

This calculation of the Present Value of money that we will have in the future is called 'discounting'.

Net Present Value

The Net Present Value of a project takes our original cash flow calculation and discounts the future income to today's value so that it is directly comparable to the capital investment, which is also at today's value. The Net Present Value of the project is:

$$\text{NPV} = \text{PV of future income} - \text{Investment}$$

So, if the NPV is greater than zero, the project is worthwhile.

Rate of Return

A slightly more sophisticated approach allows comparison between different investment opportunities. The Discounted Cash Flow (DCF) Internal Rate of Return is the interest rate which gives an NPV for the investment of zero. The calculation is not easy and the simplest approach one of trial and error on a spreadsheet. In fact Excel has a built-in DCF function.

The table below compares the cash flow forecasts for three different revenue forecasts for the novel plastic example: A is the proposal as previously stated; B and C show the effect of different rates of sales over the 10-year project life.

Year	PROJECT A			PROJECT B			PROJECT C		
	Income £'000	PV £'000	Cumulative £'000	Income £'000	PV £'000	Cumulative £'000	Income £'000	PV £'000	Cumulative £'000
0	–2000	–2000	–2000	–2000	–2000	–2000	–2000	–2000	–2000
1	–12000	–11374	–13374	–12000	–11374	–13374	–12000	–11374	–13374
2	–6000	–5391	–18765	–6000	–5391	–18765	–6000	–5391	–18765
3	2000	1703	–17062	8000	6813	–11952	4000	3406	–15359
4	4000	3229	–13833	10000	8072	–3880	4000	3229	–12130
5	6000	4591	–9242	10000	7651	3771	4000	3061	–9069
6	6000	4351	–4891	10000	7252	11024	4000	2901	–6168
7	6000	4125	766	1000	687	11711	4000	2750	–3419
8	6000	3910	3143	600	391	12102	4000	2606	–812
9	5000	3088	6232	500	309	12411	5000	3088	2276
10	3000	1756	7988	400	234	12645	5000	2927	5203
11	2000	1110	9098	300	166	12812	4000	2220	7423
12	1000	526	9624	200	105	12917	3000	1578	9001

The table below compares the profitability of the projects.

	A	B	C
Expenditure, £'000	20,000	20,000	20,000
Σ Income £'000	41,000	41,000	41,000
Profit £'000	21,000	21,000	21,000
Annual return	8.8%	8.8%	8.8%
Payback years	7.2	4.5	8.2
NPV £'000 at 5.5%	9624	12,917	9001
DCF IRR	16.8%	31.7%	18.0%

This table shows that if we calculate the profit for each project as we did at the start of this Appendix, then they all show the same £21m profit (8.8% pa). On a simple payback calculation, the best option is B followed by A and C. Using Net Present Value as a criterion gives the same result but the DCF internal rate of return shows C to be a better option than A. Option B is a clear winner because it has a much higher revenue stream in the early years when the money is worth more.

GLOSSARY

Accounts, financial Accounts (Balance Sheet and Profit and Loss) covering the financial year which companies are required to submit annually for public scrutiny.

Accounts, Management Accounts which are used by a company for day-to-day control of cash flow.

Amortisation The annual value of a capital investment spread over a number of years.

APR Annual Percentage Rate of the Total Charge for Credit – the total cost including all charges, for a loan expressed as an annual rate.

Assets, Current Assets that are continually turned over in the course of business.

Assets, Fixed Assets that are purchased for continued use in a business – e.g. buildings, machinery, vehicles, etc.

Balance Sheet A document produced annually by a company listing its assets and liabilities at the end of the financial year.

Bankrupt A company is bankrupt if its total assets are insufficient to cover its total liabilities.

BOC, Bought-out-costs Same as Costs, Bought Out (qv).

BOO, Build Own Operate A type of contract under which the contractor constructs, owns and operates a project for the purchaser for a contracted period.

BOOT, Build Own Operate Transfer A variation on BOO (qv) under which ownership is transferred to the purchaser after the contracted period of operation.

C & F, Cost and Freight A foreign trade term where the exporter, in addition to FOB (qv) charges, also pays the freight costs to the port of delivery.

Capital The total resources of a company.

Capital, Fixed Same as fixed assets (qv).

Capital, Nominal Share capital - the company's original capital raised by sale of shares.

Capital, Working Money which acts as a reservoir for the day-to-day operation of the company allowing purchase of stocks and payment of overheads.

Cash Flow The income and expenditure of a company analysed on a day-to-day basis.

CDM, Construction (Design & Management) Regulations Legislation introduced in 1994 to ensure that projects are designed with safety in mind and constructed safely by competent parties working as a team.

CIF, Cost, Insurance and Freight A foreign trade term where the exporter, in addition to C & F (qv) charges, also pays the costs of insuring the goods up to the port of delivery.

Client The company that has commissioned a project. In contracts also called purchaser.

Consultant Somebody who borrows your watch to tell you the time and then keeps your watch.

Contingency A sum of money set aside to cover liabilities that may or may not arise during a contract.

Contractor The company that has been commissioned by the purchaser to complete a project.

Contract Price The agreed sum of money that the purchaser(qv) pays the contractor (qv) for executing the contract.

Contribution That part of the contract price after the direct costs of that contract have been paid, and which goes to pay for the company's overheads and profit.

Cost Centre An accounting tool which allows staff costs to be analysed as direct costs.

Costs, Bought Out Same as Costs, Direct (qv).

Costs, Direct Costs of materials and services required to execute a contract.

Costs, Fixed The same as Overheads (qv).

Costs, Indirect The same as Overheads (qv).

Critical Path The sequence of interdependent activities which together determine the duration of the project.

D & B, Design and Build A type of contract under which the contractor is responsible for design and construction of a project.

DBF, Design Build Finance A type of contract under which the contractor is responsible for design, construction and raising the finance for a project.

DBFO, Design Build Finance Operate A variation on DBO (qv) contract under which the contractor is also responsible for raising the finance for the project.

DBO, Design Build Operate A type of contract under which the contractor is responsible for design and construction of a project and for operation for a contracted period (typically 10 or 20 years).

Depreciation The amount by which the value of an asset decreases during the financial year.

Direct Costs Costs which are attributable to executing the contracts that the company is working on, such as materials, engineering, site cabins, craneage, subcontracts, project management.

Dividend The portion of the company's profits that is distributed among the shareholders at the end of the financial year.

Ex-works A trade term in which the supplier is responsible for delivering the goods to the gate of the factory or works where it was fabricated.

FAS, Free Alongside Ship A foreign trade term where the exporter pays the all the costs of delivering the goods to the dockside.

FOB, Free On Board A foreign trade term where the exporter pays the all the costs of delivering the goods to the dockside and of loading them on to a ship.

Goodwill The notional value (set by accountants) of the company's reputation in the market place.

Inflation The falling value of money with time.

Insolvent A company is insolvent if its current assets are insufficient to cover its current liabilities.

Interest A charge paid for borrowing money.

Irrevocable Letter of Credit A method of payment in foreign trade by which the Seller presents delivery documents to the purchaser's bank in return for cash.

Liabilities, Current An accounting term for money owed by the company which must be paid within the next financial year.

Life Cycle Cost The total cost of a project during its life including capital cost, operating costs, environmental costs and de-commissioning and final disposal.

Limited Liability Company A private or public company in which no shareholder is liable for more than the nominal value of his shares.

Liquid Assets A company's assets that can be readily converted into cash – typically cash at the bank, invoices, loans and items like stocks and cars that can be sold quickly.

Liquidity The portion of a company's total assets that are liquid.

Manager, Contract The contractor's authorised and nominated representative in a contract.

Manager, Project The purchaser's authorised and nominated representative in a contract.

Marginal Selling In contracting, selling a contract at a price with reduced or zero contribution (qv).

Net Present Value (NPV) A method of project evaluation which considers the difference between the future income of the project discounted to present value and the investment.

Overheads The costs of operating the company which are not directly attributable to specific contracts.

Over-trading Taking on more business than can be supported by the company's Working Capital (qv) with the risk of insolvency (qv).

Payback A method of project evaluation which considers the time period over which the net income from a project equals the original cost.

Payment, Delayed A Progress Payment (qv) which the purchaser (qv) has failed to make at the designated time.

Payment, Progress Payments made by the purchaser (qv) to the contractor (qv) at agreed times or milestones during the contract. The sum of the Progress Payments equals the Contract Price (qv).

Payment, Stage Same as Progress Payments (qv).

Payment, Terms of The agreed way in which the Contract Price (qv) is to be paid by the purchaser (qv) to the contractor (qv).

PFI Private Finance Initiative – a government initiative to construct public projects such as hospitals and prisons using DBFO contracts (qv).

Price/Earnings The market price of a share divided by the earnings per share.

Private Limited Company A Limited Liability Company (qv) whose shares are not traded on the Stock Exchange.

Profit The money left over from Turnover (qv) after payment of Direct Costs (qv) and Overheads (qv).

Profit and Loss A document produced annually by a company summarising the company's income and expenditure during the financial year.

Provisions An accounting term for Contingencies (qv) which are identified in the financial Accounts (qv).

Public Limited Company A Limited Liability Company (qv) whose shares are openly traded on the Stock Exchange.

Rate of Return A method of project evaluation which calculates the interest rate which gives an NPV (qv) for the investment of zero.

Retention A part (typically 5-10%) of the Contract price (qv) which is held by the purchaser for a period (typically 12 months) after completion of the contract.

Share Premium A part of a company's Capital and Reserves. The difference between the nominal value of a company's issued shares and the price paid by the shareholders on original issue.

Share Price The price at which a share can be purchased on the open market.

Tender (Tender Price) An offer. The contractor's (qv) offer to the purchaser (qv) for executing the contract.

Tender Documents The documents which define the work to be undertaken by the contractor for the Tender Price (qv) and the associated Conditions of Contract.

Time Value of Money The variation of the value of money with time.

Turnover The company's invoiced sales in the financial year.

Work in Progress The value of work commenced on a contract but not completed in the financial year.

INDEX

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