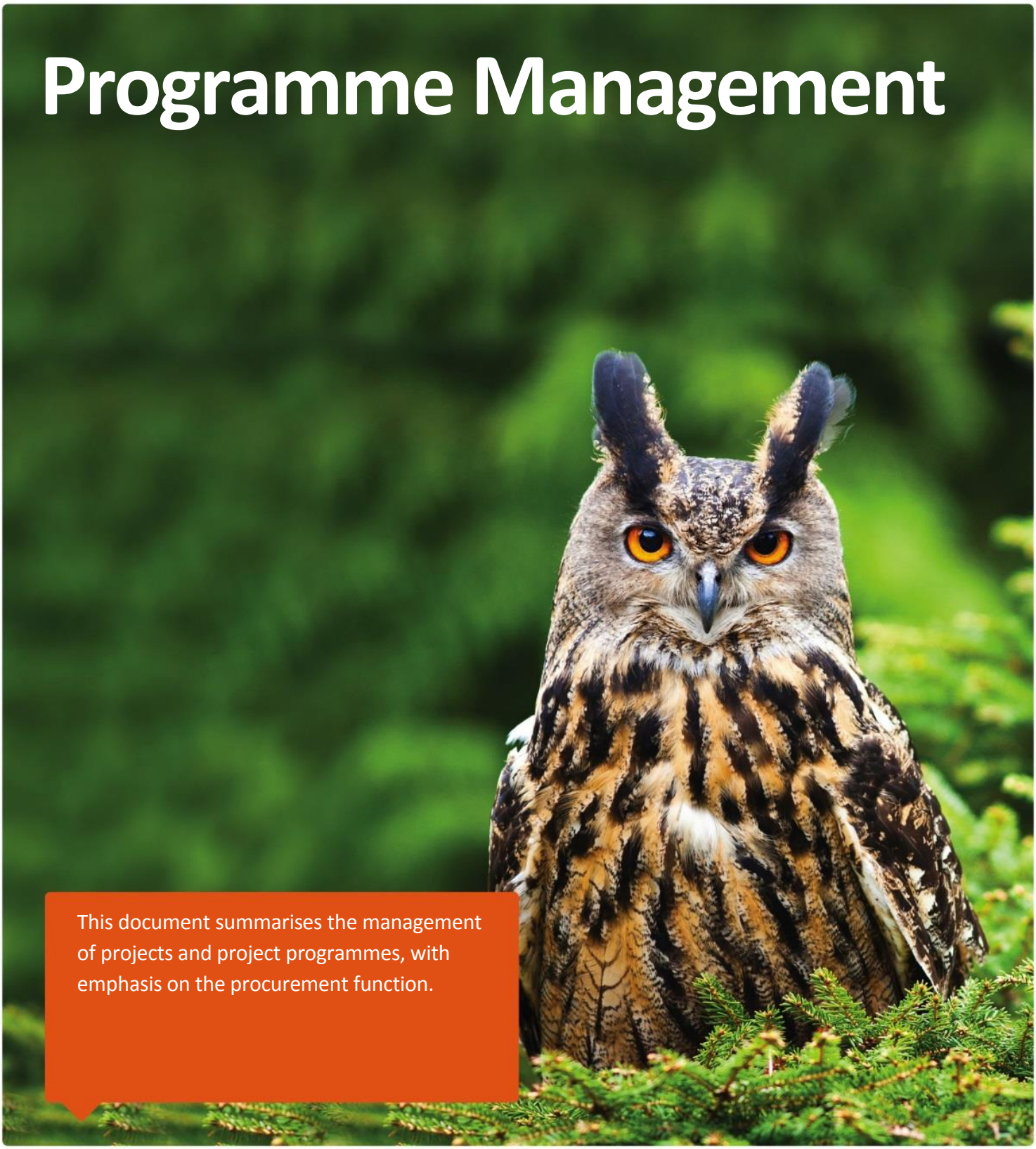
CIPS Knowledge How To

Programme Management



This document summarises the management of projects and project programmes, with emphasis on the procurement function.

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PROGRAMME MANAGEMENT

Introductory definitions

Hundreds of terms and phrases have evolved over recent decades of project and programme management and comprehensive glossaries exist in guides published by The Association for Project Management (2006) and the Project Management Institute (2004).

This section sets the scene by defining the terms 'project' and 'programme'. A shortlist of other essential definitions then follows in alphabetical sequence.

Project

The key characteristic of a project is that it is new. It is a step into the unknown that always carries an element of risk because of its novelty. Every project needs careful pre-definition, costing, planning and management, if it is to produce its intended deliverables and satisfy all its stakeholders. Lock (2007) identifies four principle categories or types of projects, as follows.

- Type 1 projects: civil engineering, quarrying, mining and construction projects. These are projects that, although planned and designed within enclosed offices, are built on sites that are usually remote from the headquarters of the main contracting organisation.
- Type 2 projects: manufacturing projects. These projects are generally carried out within enclosed premises and result in a tangible product, which might be anything from a new microchip prototype to a luxury cruise ship.
- Type 3 projects: internal and management change projects. These are projects initiated and paid for by an organisation or group for its own purposes, usually with the intention of creating future financial benefits. Examples include IT projects, mergers and acquisitions, marketing projects, organisation reorganisations, new brand or product development and organisation relocations. Most stage, screen and musical projects have similar characteristics, because they are funded internally with the expectation of future benefits. Projects conducted by not-for-profit organisations often belong to this type, even though they may not result in financial benefit for the project owner.
- Type 4 projects: projects for pure scientific research. These laboratory projects cannot usually be defined with any accuracy, carry enormous risk of failure, and may not be amenable to project planning and management processes. One thing that these projects do have in common with the other three categories is that they need the procurement of goods and services.

These project classifications are, of course, generalisations and there are exceptions. However, they are convenient when discussing project and programme management.

Programme

A programme is a mix of projects in an organisation. For example, a civil engineering or construction organisation might be conducting several projects concurrently for different paying customers. Those, together, can be classed as a programme of projects. At the same time, that organisation might wish to introduce some internal changes, such as a reorganisation, a new IT system, or the relocation of its headquarters offices. These Type 3 projects would then become part of the programme mix. The total programme mix is often called the project portfolio.

With exceptions that are too rare to consider, every project has a finite life. But the life of a programme has a duration that marches with the life of the organisation itself, although the programme content will be dynamic, constantly changing with time, as new projects are added and others are completed or abandoned.

Other essential definitions

Contractor — Throughout this document the term contractor is used to describe the organisation that manages and performs the project work. The contractor will often delegate tasks to external agents and sub-contractors.

Procurement — No CIPS member will need this definition, but it is included here for the benefit of 'lay readers'. Procurement is the function of obtaining all the goods and bought-in services that an organisation, or other organisation, needs for its projects and other operations. Procurement and supply chain management includes the appraisal, rating and selection of vendors and the formulation and conclusion of contracts. The procurement of any good begins with a specification of the requirement and does not end until the good is delivered fit for purpose, to a safe and secure place, at its required point of use, at the right time, in the right amount, and at the right cost.

Project owner — The project owner is the project customer, the organisation or organisations that commissions and pays for the project, and will own the project after its completion and handover by the contractor. Because Type 3 projects are commissioned in-house, the project owner is also the project contractor. A few companies call their project managers 'project owners' because they 'own' responsibility for their projects. Those companies create an internal contract for each project in which the two main parties are the organisation and its project manager. Because these practices can give rise to confusion between the identities of the real project owner and the project manager, they will not be assumed in this document.

Scheduling — A process that begins by placing all identifiable tasks or activities in a logical sequence. The process continues by estimating duration times for those tasks, and by establishing which tasks should claim the highest priority for management attention, and the allocation of scarce resources. Throughout this document, it will be assumed that scheduling is conducted using the critical path method, supported by a computer loaded with competent software, used by planning engineers, or others who are fully trained and experienced for the purpose. Later in this document, the value of a project or programme support office will be stressed in this context.

Stakeholder — A stakeholder is any person or organisation that will be effected by the project or has an interest in its execution and outcome. For example, in a project to build a new shopping mall, the property developer, the banks and other financing institutions, the shareholders, the contractors, the workers, the eventual tenants, the shoppers, the public utilities, the local authority, and the local residents are all stakeholders. Large projects have stakeholders at different levels, so that the owner, other investors, and the main contractor are primary stakeholders, and others with more indirect interests are secondary or tertiary stakeholders. Hartman (2000) declares that a successful project is one that satisfies all its stakeholders. Consideration of stakeholders' interests is always important and we must applaud Hartman's admirable goal. However, it must be accepted that it is not always possible to satisfy the interests of every secondary and tertiary stakeholder.

Work breakdown structures (WBS) and coding systems

Work breakdown is the process of dividing a project into smaller parts which can more easily be visualised, costed, and managed. The WBS process begins early in the project life and becomes refined with time as more information about the project becomes available. A WBS is a hierarchical structure in the fashion of a family tree, with the programme or project at the top, and with the smallest components or tasks occupying the bottom level. Devaux (1999) puts the case for the WBS cogently and is good, generally, on planning. Key to any work breakdown structure is its coding system. A code must be allocated to every part of the WBS. The coding should be hierarchical so that the code for any particular element identifies the element itself, the level or layer of the WBS to which it belongs, and its relationship with other elements to which it is directly connected (either physically or by cost). No relational database can operate without a logical coding system. Coding systems are described in Lock (2007).

Project life cycles

Every project has a finite life, which passes through a number of phases. The boundaries between some of these phases may be indistinct, and phase overlapping is common. However, key events or milestones can usually be identified that usher in each new phase or signal the end of a dying one.

The term ‘life cycle’ is indicative of a natural cycle of birth and regeneration, but projects do not really copy nature in that way because each is individual, and travels from birth to final, obliterating death. A project has no soul! However, we shall adhere to the common convention and continue to call the passage of a project from beginning to end its ‘life cycle’.

A popular misconception to dispel is that a project life cycle begins when work starts on the project and ends when it is finished and handed over to the customer or end-user. That definition really describes only the fulfilment phases of a project. Many textbooks fall into this trap and most do not even mention the procurement phase.

The true life cycle begins when the project is initially born as a concept or entrepreneurial idea, and does not end until the project outcome ceases to be of practical use. Thus a Type 1 or Type 2 project life cycle will end when the original product is decommissioned, demolished, or sold for scrap. The end of a Type 3 project life cycle can occur for a variety of reasons, but it is usually attributable to further management change projects or the end of the organisation in its current form. Typical life cycle phases for industrial and management change projects are illustrated in Figure 1.

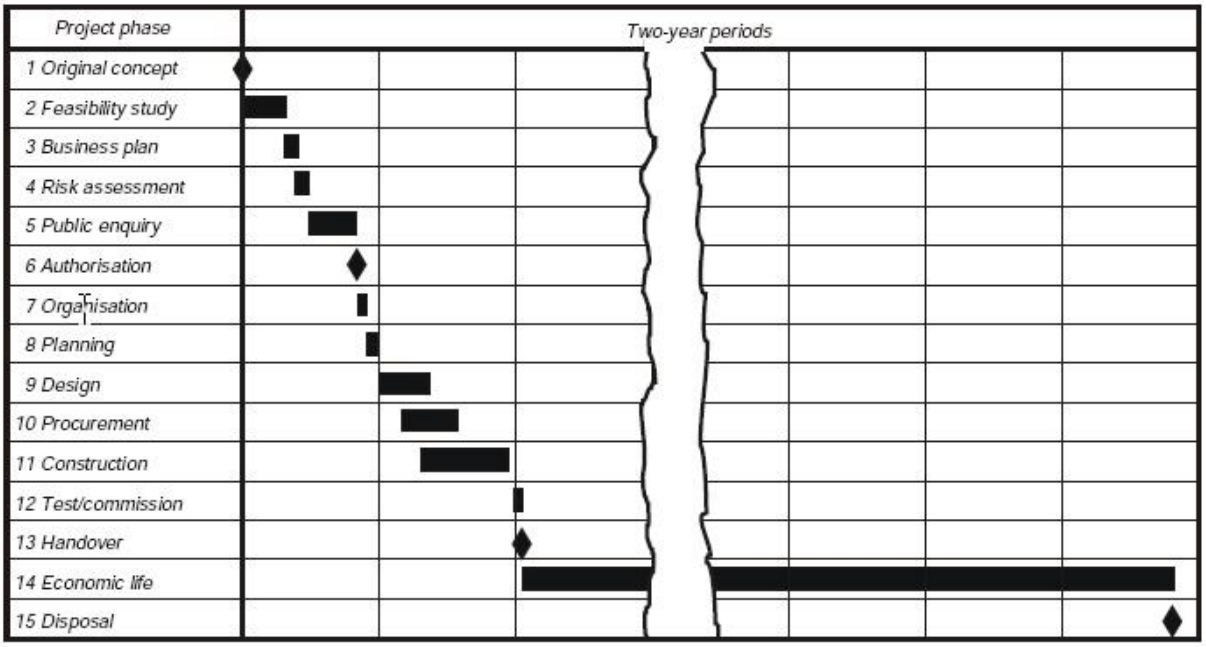

Figure 1 A typical life cycle for a large industrial project

Type 4 (pure research) life cycles are different and unpredictable. An effective way to keep control of a research project is to conduct regular management reviews, on the understanding that each review will either authorise a fresh tranche of funds (allowing the project to continue to the next review) or pull the plug on the project and redeploy the research team or disband it. This process is called 'stage gating'.

Net cash-flow and benefit realisation

Most companies undertake projects and programmes to realise benefits that can ultimately be quantified in financial terms. Thus, to understand the characteristics that classify a project as 'successful' it is necessary to have some idea of the relationship between costs, revenues and profits. And that means understanding the principles of cash-flow management.

Costs are *cash outflows*. Revenues and other incomes (including authorised borrowings) are *cash inflows*. The differences between cash inflows and cash outflows are the *net cash-flows*. Anyone who manages their personal current bank account without incurring unauthorised borrowings will understand these principles. However, some project managers concern themselves only with cash outflows, and many erroneously refer to cost reports as cash-flow reports. Project engineers often do not even concern themselves with costs at all. Thus, before delving more deeply into the subject of programme management, we need to define what is meant by cash-flow management and benefit realisation.

Typical project cash outflow (cost) patterns

Most projects display the kind of cost pattern shown in Figure 2. Once a project has been authorised to start, the rate of expenditure is at first slow whilst the organisation is put in place and initial detailed planning, scheduling and design begin. Then, when the first purchase orders are issued and work begins on the physical tasks, the expenditure rate rises rapidly. When work begins to tail off, as the project nears completion, so the rate of expenditure also tails off, and the graph becomes asymptotic towards the final cost (which, of course, should not be allowed to exceed the total cost budget).

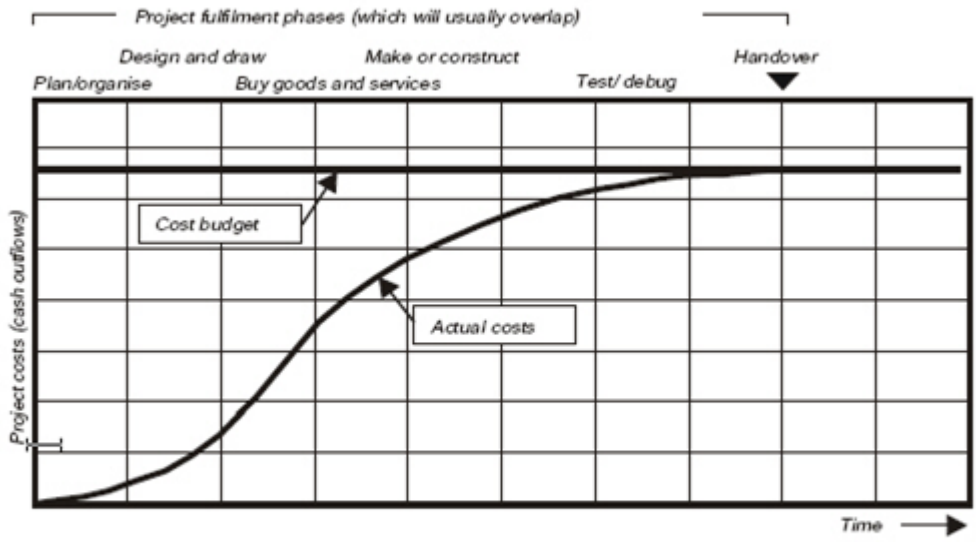

Figure 2 Typical project expenditure pattern (the 'S' curve)

All project managers are familiar with these graphs which, because of their characteristic shape, are always known as *S* curves. All Type 1, 2 and 3 projects display similar cost patterns, although they seldom produce a curve as smooth as that shown in Figure 2. The cost curve for a Type 4 (pure scientific research) project can be almost linear — a line that climbs with time until either a result is obtained or someone pulls the plug on the project.

Net cash-flows patterns for single projects

To calculate the net cash-flows pattern for a project it is necessary to set out all the cash inflows and cash outflows in a spreadsheet in the manner of that shown in Figure 3. This should be done using estimated values before the project starts, and then repeated using actual values for comparison and control purposes as the project proceeds.

ST ALBANS MEGASTRUCTURES plc — Predicted cash flows for the Lox Mansion project — Issue date November 2008

	Cost code	Quarterly periods - all figures £1,000s																Total budget
		2009				2010				2011				2012				
Cash inflows		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Client's payments	SAM	50	-	-	-	150	100	250	300	300	350	400	400	300	100	50	-	2750
Total inflow s		50	-	-	-	150	100	250	300	300	350	400	400	300	100	50	-	2750
Cash outflows																		
Engineering	E1000	10	30	50	50	20	10	5	2	2	2	2	2	2	2	-	-	189
Purchasing	P1000		-	-	50	100	250	120	100	200	200	150	25	5	2	-	-	1202
Construction	C1000		-	-	-	25	100	100	100	150	100	100	100	40	5	-	-	820
Total outflows		10	30	50	100	145	360	225	202	352	302	252	127	47	9	-	-	2211
Net cash flows																		
Periodic		40	(30)	(50)	(100)	5	(260)	25	98	(52)	48	148	273	253	91	50	-	
Cumulative		40	10	(40)	(140)	(135)	(395)	(370)	(272)	(324)	(276)	(128)	145	398	489	539	539	539

Figure 3 A contractor's cash flow schedule forecast for a project with contractual stage payments

Cash-flow forecasts are always important, but they are particularly so for Type 3 projects. A predicted cash-flow schedule is an essential ingredient of the pre-authorisation business plan for every proposed management change project.

The elements in the spreadsheet cannot be calculated before the project has been defined in some detail and a work breakdown structure or task list has been compiled. Then the best possible cost estimate must be made for each item. A provisional project schedule will allow the estimated costs of each item to be placed or spread over its expected position in the project time frame.

A large project will require several such spreadsheets, compiled in a hierarchical fashion that agrees with the work breakdown structure. The cash-flow from the pages at lower levels must be rolled up into a summary spreadsheet for the project.

The example for a single project given in Figure 3 shows that the contractor will expect to have a shortfall of funds for most of the project's life cycle, although stage (progress) payments received from the customer will do much to reduce the amount. It can be seen that in the second quarter of the year 2010 the contractor must expect to fund work in progress to the amount of £395 000.

Should the contractor decide to make provision for those shortfall funds by borrowing from a bank or other external source, the amounts to be drawn down from the loan agreement will be shown at their expected times on the cash-flow schedule in an additional row under the 'cash inflows' heading. The corresponding repayments of the loan principal and loan interest must then be inserted in additional rows in the 'cash outflows' section.

Understanding essential differences between the cash-flow patterns for different types of projects

Type 1 and Type 2 projects will produce cash flow patterns that differ considerably from those of Type 3 projects. Type 4 (pure research) projects often cause a steady, unrelieved outflow of funds. These differences are shown graphically in Figure 4.

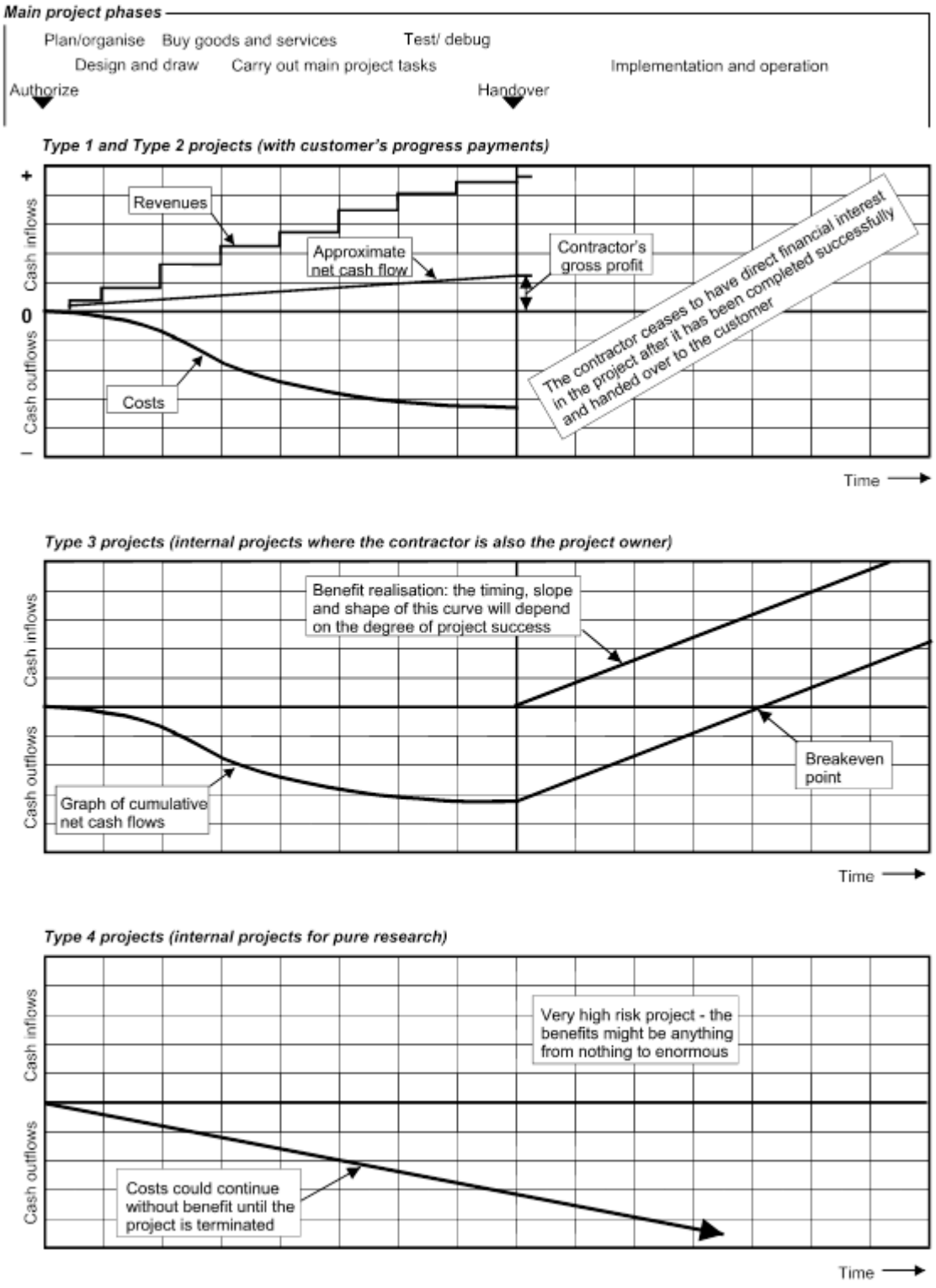

Figure 4 Typical cash flow patterns for different types of projects in a contracting company's programme mix

One point to note about every curve in Figure 4 is that the cash outflow (cost) curves have been inverted from the S curves familiar to most project managers. This inversion is logical mathematically because costs, as cash outflows, are negative quantities.

Projects classed as Type 1 or Type 2 will usually be carried out by the contractor (or contractors) against funds provided by a paying customer, although the contractor may have to fund work in progress during the project design, procurement and execution phases. The project selling price should exceed the total project funding and yield an immediate profit for the contractor on project completion and handover.

In large projects the contractor's net cash-flow position is often protected to a great extent by the contractual terms of payment. The customer agrees to make progress payments (stage payments) against independently certified claims for payment at periodic intervals during the project's design, procurement and build phases, or upon the achievement of predetermined progress milestones. The spreadsheet shown in Figure 3 includes stage payments.

Projects classified as Types 3 and 4 have a fundamentally different financial pattern from those in categories 1 and 2, because they are usually paid for from the organisation's own capital reserves or from loans, and the organisation cannot realise the full financial benefits until well after the project has been completed and fully implemented. Thus an internal management change project requires the organisation to fund all the work in progress, and the cash inflows will not begin until the project has been finished and the operational improvements that it creates show cost savings or other financial benefits. However, when the project is successful, those benefits will accrue to the organisation for many years into the future. Whereas commercial Type 1 and 2 projects are conducted to achieve short-term profits, management change projects should instead produce future cost benefits in a prolonged process that is called benefits realisation. See, for example, Bradley (2007).

There is an important cash-flow exception for Type 4 projects, which is when one organisation that owns laboratory facilities undertakes a programme of research for another organisation (which might be a organisation or a government department) under a cost-plus or cost reimbursable contract. Here the research laboratory (the contractor) is providing an expert service, for which it can claim and receive frequent and regular payments to offset its cash outflows, usually marked up to provide a steady and reliable profit revenue for the contractor. Then the customer carries the burden of cash outflows and bears almost all the considerable risk.

The relationship between the procurement function and cash-flow management

The extent of the financial influence

For any project the proportion of total costs attributable to bought-in goods and services is likely to be very significant. Purchases typically account for over 50 per cent of the total cost, and for some projects can even be as high as 80 per cent. It is clear that purchasing will have a considerable impact on each project's financial performance and, therefore, on the organisation's net cash-flow position.

Unfortunately, the procurement role is commonly undervalued or even disregarded. For example, most writers ignore the contribution that procurement can make to a project's success or failure. If you find yourself at a loss for something to do one wet afternoon, go to your nearest reference library and gather an armful of all those books that deal with project

and programme management. Then look for the words 'procurement', 'purchasing' or 'supply chain' in their contents lists. Nothing there? Then look in the detailed indexes at the back of those books. Astonishingly, you will find that this most important subject is often completed ignored.

Minimising cash outflows

The following are among the key actions that keep a contractor's cash outflows (costs) under control:

- Define each project as well as possible before work is authorised to start
- Avoid unfunded changes to the project (including purchase order amendments)
- Perform all critical tasks on time (because late tasks attract higher overheads)
- Do not schedule goods deliveries too early (which also mean not paying for them too early). Although just-in-time purchasing may not be appropriate for projects, the use of call-off deliveries for bulk supplies can spread payments to suppliers. However, a good delivered two weeks early is not nearly such a big problem as the same good delivered two weeks too late
- Operate sound purchasing practices, including competitive tendering for higher-priced goods and always remember that materials' cost control takes place before or when purchase orders are issued – afterwards what is often called 'cost control' is really only historical cost reporting
- Scrutinise all suppliers' invoices and don't pay before the goods have been received in good condition, or too soon, before the credit period expires.

Maximising cash inflows

- For all but the smallest, short-duration projects, arrange for the customer to make progress payments and record those arrangements in the terms of payment in the contract
- Perform all critical tasks on time (this repetition of item 3 above is not an error) because tasks that run late will delay the times when interim or final invoices can be issued to customers
- Issue invoices to customers on time and avoid errors that could provide excuses for non-payment
- Turn customers' requests for project changes to your organisation's advantage – remember that these need not be priced keenly because there are no competitors for work done under contract variations
- Pursue debtors

The trauma of cash-flow difficulties.

When a manager signs off a supplier's invoice for payment, he or she assumes that the accounts department will issue a cheque and that the invoice will be paid. However, if the contractor is experiencing a cash crisis, that might not happen when it should. When a organisation runs short of cash, its creditors occupy different positions in a strict pecking order. First, comes the payment of government taxes. Payment of wages and salaries is usually given high priority. Payments to suppliers and other creditors can come fairly low down in the order.

As soon as payments to one or more suppliers fail, or are made very late, word will spread throughout the commercial world. Under those conditions, the lives of purchasing managers and their expeditors suddenly become very difficult and stressful because, on the one hand they are trying to obtain goods with which to feed the revenue-earning projects and stifle the clamour from the project managers, while on the other hand the suppliers feel less than enthusiastic about providing future supplies. In the worst case, suppliers could withhold

deliveries altogether pending payment of their outstanding invoices. So the downward spiral to insolvency begins and accelerates. Anyone who has worked under those conditions (as this writer has) will receive a sharp, practical lesson in the importance of cash-flow management.

If a cash-strapped contractor's project portfolio includes one or more expensive and ambitious internal management change projects, the managers of Type 1 and Type 2 projects will feel aggrieved that the success of their projects is being put in jeopardy by this diversion of cash. Then, the purchasing department and its buyers will justifiably feel very angry that this cash wastage makes it difficult or impossible to obtain supplies for revenue-earning work. This is just one of the reasons for getting the portfolio balance right.

Managing the project portfolio

Every business organisation will usually have at least two fundamentally different activity streams. One of these is the revenue-earning projects or service activities, which the organisation sells and upon which it depends for its survival and growth. Successful companies will maximise this area of their business, and will attract as much work as possible, with the expectation of profits. The funds derived from those profits, after paying tax, provide incentives to investors, such as shareholders. But some of those profits and other funds will often have to be diverted to Type 3 or Type 4 projects that are intended to increase the organisation's potential for future profitable work.

Attracting and authorising new commercial projects for the portfolio

Clearly, senior management must always seek to maintain or increase the amount of profitable work that comes into their companies. This is typically achieved through reputation and marketing and (depending on the type of organisation) through submitting successful tenders for new projects. Subject to avoiding the trap of overtrading, the organisation will want to accept as much revenue-earning work as it can get. If the organisation is a contracting organisation, it will be seeking to add as many Type 1 or Type 2 projects to its project portfolio as it can handle.

Procedures for authorising new commercial projects for external (paying) customers are usually well established within contracting companies. The deciding factors for authorising or rejecting a new project include the following:

- How well the scope and nature of the work is defined
- The financial status and commercial reputation of the intended customer (will the bills be paid in full and on time?)
- The degree of assessed risk
- Whether or not the proposed project falls within the contractor's sphere of competence
- Whether or not the necessary resources are available, or can be made available
- The ratio of the expected profit margin to the estimated costs.

If all these signs are good, the contractor will probably decide to accept and authorise the project. Once a contract is made, the contractor will issue an internal document, such as a works order, that informs all key managers of the project's essential details, announces the name of the project manager, allocates a project name and number, and permits expenditure within budget to start.

Screening and authorising internal management change projects

The process for considering and authorising management change projects is quite different from that for revenue-earning commercial projects. We have already demonstrated that these internal projects can never create immediate profits, but will certainly add substantially to current cash outflows. They often carry high risk of failure and their intended benefits can be difficult to quantify.

However, in any organisation or group of significant size, the senior management will usually receive many requests from managers for internal changes that claim to offer irresistible future benefits. Unlike commercial projects, where the problem is often an uncertainty as to where the next project work is coming from and maintaining a full order book, the difficulty for the senior managers of large companies is now reversed. They often have to fend off some suggestions for internal projects that will certainly cost money but might not yield the benefits promised by the initiators.

When an internal management change project is added to the portfolio, it will drain cash in the short term, even if it eventually realises all the intended benefits. Its inclusion in the portfolio can divert scarce resources from revenue-earning activities.

Management change projects that fail are also expensive, because of the damage that they cause to staff morale. Most management change projects require some staff to accept and learn new working methods. The more ambitious projects cause organisational changes that require some staff to leave and others to accept new roles in a changed organisation. If all that effort fails, owing either to a flawed business plan or poor project management, the culture of the organisation will be damaged. Any future management change project will be treated with suspicion and with either apathy or outright hostility, and so performance of revenue-earning operations will suffer.

Thus senior management must strive for a balanced and well-considered portfolio, ensuring that it contains a mix of projects weighted in favour of those that will bring in revenues and protect the cumulative net cash-flow. Only those internal projects that are supported by a sound business plan and align with corporate objectives should be considered for authorisation.

The senior management of a large organisation or group can expect to receive concurrent suggestions for internal projects from several managers. Not all those suggestions will be motivated by sound organisation motives: for example, it is not uncommon for managers to suggest schemes for reasons of personal career advancement or because of peer pressure from their management colleagues. To enable senior managers to assess and compare the individual merits of these applications and decide priorities for acceptance, the originators must be asked to submit business plans. Every business plan should be prepared to a standard organisation format, and each should include at least the following:

- A clear statement explaining the nature and scope of the proposed project
- A description of how the proposed change will affect the organisation and its staff
- A schedule of the expected benefits, with every item (including the intangible benefits) expressed in financial terms and placed in its expected time frame
- A plan showing the outline timescale of the project and the period of implementation, with key events listed and highlighted

- A cash-flow schedule. Cash-flow schedules that exceed one or two years should be discounted at a rate not less than the organisation's expected internal rate of return on investment (IRR) to find the expected net present value (NPV) of the project. See Dayananda et al (2002) for a good explanation of investment appraisal methods
- A risk assessment, listing all foreseeable threats
- A statistical analysis of the costs and benefits, preferably using the Monte Carlo probability method to predict the worst, most likely and best results.

Some larger management change project proposals are so complex that they present more than one possible course of action. For example, moving the headquarters of a large organisation can be a huge, expensive, disruptive, risk-laden undertaking, and there will usually be widely different opinions about where the new location should be. Thus there might be more than one possible business plan, each supporting a separate case, so that a feasibility study must be carried out to assess the merits of each possible case and a report prepared, with recommendations. This will assist senior management in deciding not only whether or not to authorise the new project, but also to choose between the different cases. A feasibility study for a large management change or investment project can itself be a big project, costing many millions of pounds.

Management change projects occasionally have to be accepted and added to the portfolio, even when their net present values and visible cash benefits fall short of the organisation's usual acceptance level. Prominent among these are projects undertaken for health and safety. For example, a hotel organisation may have no choice other than to undertake expensive internal project works in order to obtain fire certificates for all its premises, without which the organisation could not continue to trade.

Avoiding technical and organisational conflicts within the portfolio

Management change projects, because they are so invasive of the organisation's normal organisation, can conflict with each other. It is very possible that two proposers, unknown to each other will each suggest a management change project that although individually sound in concept, would lead to conflict, mayhem and chaos if the two were allowed to proceed together. For example, it would be unwise to redesign a organisation's cost accounting systems based on the existing IT, when a different management change project was being conducted independently to replace the IT systems.

An organisation that is enthusiastically pursuing a project expected to increase efficiency, and reduce staff requirements, would be unwise to a conduct a recruiting drive for more permanent staff. This could happen if poor management communications kept some departmental managers in ignorance of the new internal change project.

Thus it is important that someone in the organisation has a composite view of programme strategy, and has enough knowledge of the corporate objectives, to be able to recognise potential conflicts before unwise internal projects are allowed. The programme director is one person who might perform that role.

Total cost consideration

Sellers of office equipment sometimes make extravagant claims for the financial benefits that their particular goods or systems will bestow on the buyer's organisation. A similar argument applies to the proposers of new internal change projects, and they are apt to present their

financial justification with an optimistic bias, either innocently or intentionally. Those charged with the considerable responsibility of authorising, or rejecting such projects, run the risk on the one hand of authorising a new project where the financial data are fundamentally flawed, or on the other hand of turning away a request for a project that would, in fact, have produced good financial benefits in the longer term.

One test that senior managers can apply is to ask whether or not the cost estimates embodied in the business plan are indeed the total costs. For example, one IT project in this writer's experience failed financially because its business plan did not allow for the following circumstances:

- The project, far from achieving the forecast reduction in staff numbers, actually required more staff in the general organisation departments and, also, more expensive staff to run the new computer
- Had staff been made redundant by the project, there was no provision for redundancy costs payable to compensate the released staff
- There was no provision for staff training costs
- A clean power supply, raised sub-floor, air conditioning and automatic fire protection had to be provided, but neither those things, nor the basic accommodation itself, had been allowed for in the estimates
- The equipment cost was correctly shown as a capital purchase sum, but the subsequent annual operating costs of the maintenance contract and substantial 24-hour electrical power supply costs were not included.

Thus anyone charged with authorising or rejecting a management change project needs to examine not only the forecast benefits, but also the total cost implications of the project.

Time spacing changes that affect the same internal functions or systems

The relatively long period leading to benefit realisation for an internal change project, when compared with other kinds of projects, means that the success or failure of an internal change project cannot be measured until sometime after the introduction of the change. For a qualitative assessment of the change's effect it is usually necessary to compare 'before' and 'after' figures. These figures will usually apply to one or more entries in the organisation's accounts.

For that reason alone, it is bad policy to introduce a new internal change project into a system whilst another change to the same system is in progress. After one full accounting period has elapsed the effects of the first change can be measured.

In this context it is also important to remember the disruptive (even demoralising) effect that changes often have on staff. *The success of every internal change ultimately depends on staff accepting and implementing the change willingly*. If you attempt to introduce a new change into a department or system where another change is undergoing implementation, that will be asking for obvious and avoidable trouble.

Organising industrial and commercial projects

This section introduces the complex but important subject of project and programme organisation. Although there is space here only for a summary discussion, the more important principles can be explained and illustrated. For further reading, Lock (2007) and Meredith and Mantel (2003) give fairly full accounts of project organisation. Buchanan and Huczynski (2003)

go into far more depth. (These accomplished authors must have had their tongues firmly in their cheeks when they called their 900-page tome 'an introductory text').

A suitable project organisation will enhance communications between all the project participants. It will also help each project manager to motivate all the people involved towards meeting the project goals. The converse is true when an inappropriate organisation will contribute to project failure.

Although particular organisation structures can be recommended for certain kinds of projects, the rules are not hard and fast. The final organisation choice must depend on geography, the organisation culture, and other factors, such as whether project completion on time or long-term organisational stability is the dominant goals. Examine two different companies conducting similar projects and their organisations might be found to be quite different, although both companies might be equally successful. Ask a group of people from different companies to draw charts (organograms) of the organisations in which they work, and you will find that there are almost as many organisation structures as there are companies. However, senior managers who set out to establish project or programme organisations in their companies must understand the basic organisation structures that are outlined in the following paragraphs.

Matrix organisations

Figure 5 shows a matrix organisation. Suppose that a organisation undertakes an industrial project for the first time, and has to mix the project work with its routine operations. There is no one in the existing organisation that can view the project holistically and ensure that it progresses smoothly, from one functional department to the next. The wise approach is to appoint a person to plan and coordinate the project's progress across all the diverse functional departments that will perform the project tasks.

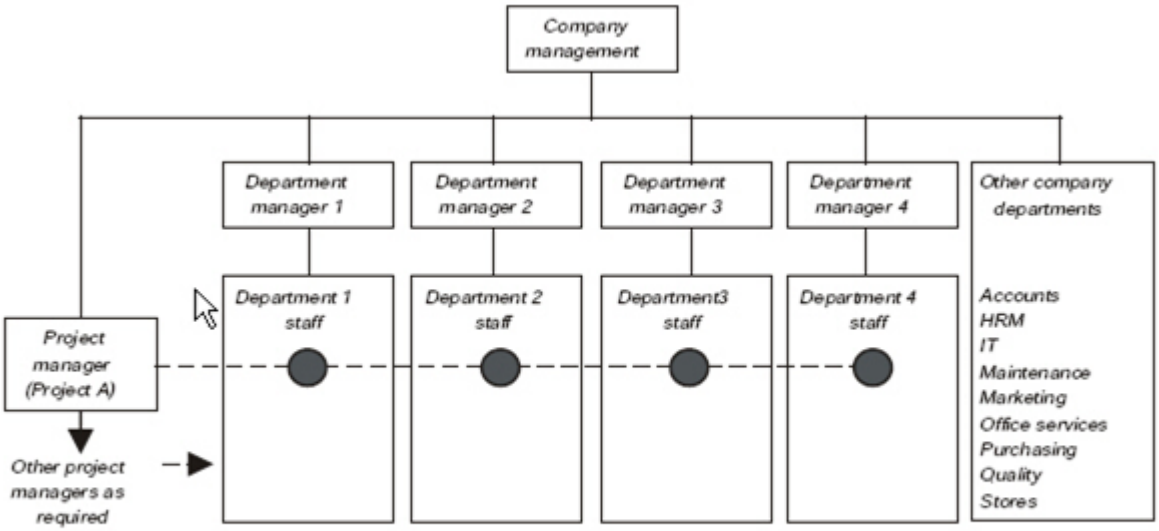

Figure 5 Characteristic form of a matrix organisation

Note that the chart in Figure 5 places the purchasing function among 'other organisation departments', which is a common, if unwise, view.

So far this describes a weak matrix organisation, in which the project manager has no line authority. He or she can only plan and coordinate the project tasks.

A balanced matrix organisation has the same physical structure as a weak matrix, but the project manager is given some line authority and is expected to share decisions on project tasks with the functional (departmental) managers. For example, a chief civil engineer might have to agree with the project manager on which tasks should be performed by the civil engineering department on a particular day. The theory is fine but it has the drawback that anyone working in a functional department is suddenly faced with two bosses. If the instructions of the departmental manager conflict with those of the project manager, mayhem is triggered and despair follows. It is said that a balanced matrix violates the principle of unity of command.

Because no real project team exists, the project manager will find some difficulty in motivating people to identify with the project and to feel that they are part of a virtual team. Also, project communications tend to be slower in a matrix because commands and data have to cross departmental boundaries.

Stronger forms of the matrix are sometimes used, in which the project manager can overrule the departmental managers. The secondment matrix is the strongest form, where the project manager can ask for named individuals to be seconded to work on his or her project. Strong matrix forms share some of the characteristics and advantages of project teams, which will be described next.

A big advantage of any matrix organisation is that the main structure of the organisation can continue unchanged as projects come and go. In theory, individual members of staff can look forward to steady career advancement within their own specialist functions. A matrix is also considered to be good for quality of design because functional expertise is concentrated within each group under the expert guidance of its specialist manager.

When the organisation begins to undertake more projects, it can appoint more project managers to oversee them, with each having his or her own lines of communication, influence, or even command across the functional departments. There is a hint of that development in the bottom left-hand corner of Figure 5.

Project team organisations

Figure 6 shows an organisation structure that is completely the opposite of the weak or balanced matrix. This is a project team organisation.

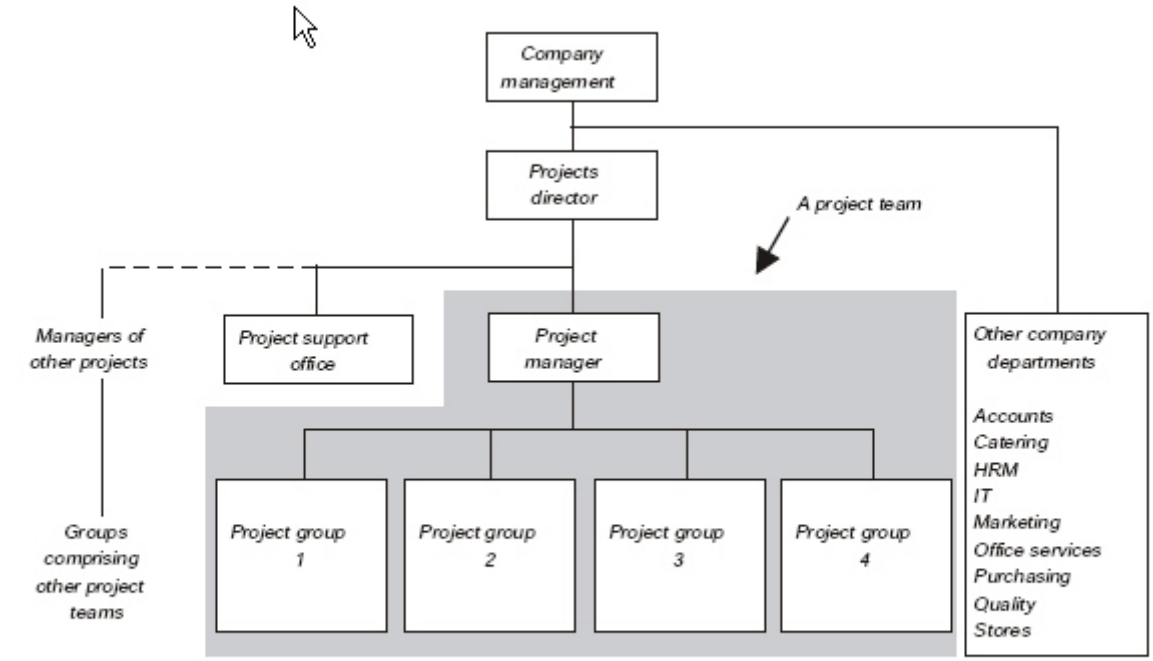

Figure 6 A project team organisation in a contracting company

With any team organisation there is no conflict of command and no doubt about who is in charge of the project because the project manager is given unequivocal line authority. Once again, the purchasing function is often excluded from the team and relegated in the chart to 'other organisation departments'.

The advantages and disadvantages of team organisations are the opposite of those claimed for the weak or balanced matrix. Team spirit and motivation are more easily engendered. Communications are fast, not hampered by inter-departmental boundaries. People work alongside others working on the same project, and they can all identify themselves closely with the project and its success or failure. But, as a project begins to draw to its close, the team members can become demotivated when their thoughts begin to drift away from completing the remaining project tasks towards where (or if) they will be working when the current project ends.

The example chosen for the illustration in Figure 6 is for an organisation carrying out a number of concurrent Type 2 (manufacturing) projects. The arrangement for a construction organisation's headquarters would be similar. These Type 1 projects could also be remote site construction teams, each of which would probably have its own site manager who reports back to the relevant home-based project manager.

The choice between matrix and team organisations

In general, a matrix organisation will suit an organisation that has many small projects continuously entering and leaving its order book, while a team favours larger individual projects, especially when completion on time is particularly important.

Hybrid organisations

Some companies operate as a matrix, but set up teams for special projects when the occasion demands. For example, a team or task force might be set up for a project (or even part of a project) that is particularly urgent. That particular application is described below in the sub-section headed 'Corrective measures' within the main section 'Controlling and correcting works in progress.'

A very small project could be assembled within the electrical engineering department for a project to install a big new transformer for a client That project will involve mainly electrical design tasks and no other functional department will play any significant part in that particular project. A pumping project could be based wholly within a piping and fluids department.

A construction organisation that operates a matrix organisation at its headquarters will certainly have to establish a self-contained team at each significant site. Large site organisations recognise the importance of purchasing by having a materials controller to oversee goods arrivals, secure storage and to undertake some local purchasing.

The organisation of any organisation that customarily carries out industrial or commercial projects, and then finds itself also conducting one or more internal change projects, will almost certainly become a complex hybrid organisation.

Organisational changes required when an organisation begins to undertake multiple projects for paying customers

When an organisation is successful in attracting project orders, and the trickle of projects has become a flood, a project director is often appointed to report to senior management and oversee the project managers and the project programme. The projects director, with an overall view of the project workload, is the person best placed to advise senior management on the organisation's ability to accept new work, and he or she can forecast future manpower needs. A project programme support office can assist the project's director in this planning and scheduling role.

These developments were introduced in the team organisation shown in Figure 6 and would also apply to a multi-project matrix organisation. The role of a project or programme support office will be described later in this document.

Organising internal projects and mixed project programmes

Management change projects differ in many respects from industrial and commercial projects. They often occur in service companies (banks, insurance, catering, retailers, service providers and so on) that have no other experience of projects. Even in companies that do normally carry out projects as part of their everyday activities, a management change project will usually effect administrative departments that would not usually take part in project tasks (such as HRM, IT, accounts, marketing and purchasing).

Case example 1: an internal project in a service organisation

Figure 7 shows how an internal management change project might be arranged in a service organisation (an insurance organisation in this instance). This organisation has little experience of projects or their management, but its board has decided to approve a large internal project (it might be new IT or a organisation move, for example). Because the board collectively has no project expertise, it has placed some of its directors in a steering committee. Their prime job is to represent the main board in all decisions effecting the direction and scope of the new internal project. Unless the main board directs otherwise, the steering committee must always be bound by the intentions expressed in the business plan for that project.

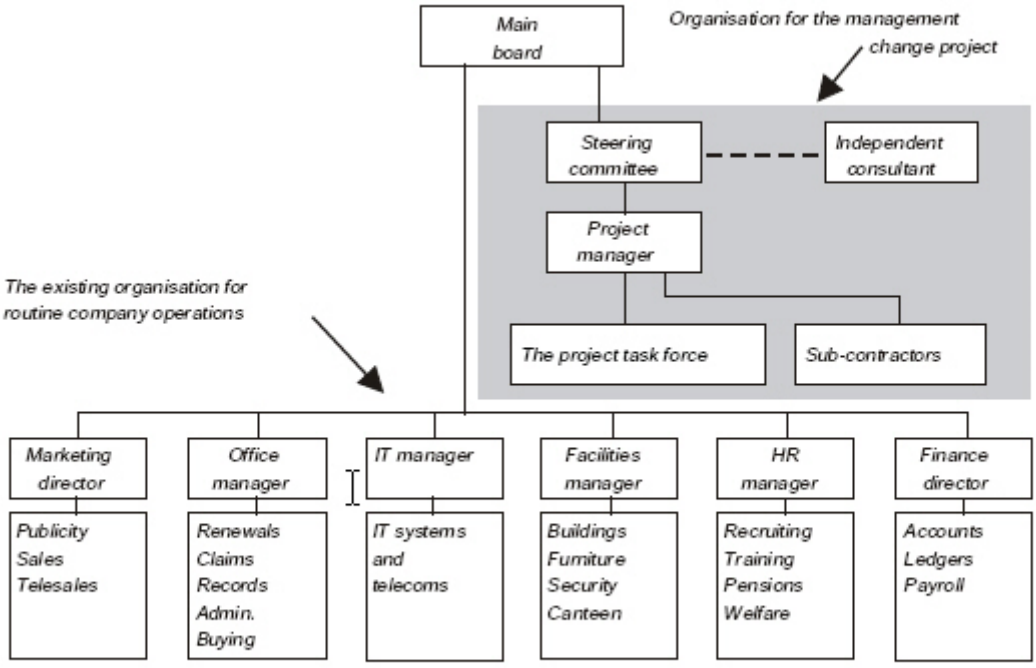

Figure 7 A service company with one large management change project

To assist the steering committee, an external consultant who does have considerable experience of management change projects has been appointed. Although the external consultant acts in an advisory role, it would be a very unwise steering committee that failed to heed his or her advice. It is important to avoid any possible conflict of interests, so the external consultant must be entirely independent of other external companies that might later be sub-contracted to provide facilities (such as premises, equipment, office systems or IT) for the new project.

A project team organisation is always indicated for a management change project, because a team will have the good internal communications and motivation needed to plan and coordinate all aspects of the project. This will drive it through to successful completion, including successful implementation and gaining acceptance for the project from the organisation's staff. Such a team is better described as a task force.

It is wise and customary to staff this task force with the most senior and more competent people that can be found from the organisation's functional departments (one or two from each department). These people should be released from their normal duties and be seconded to work for the project manager. That approach has the big advantage that each functional department will be represented in the new project development. This will help to prevent mistakes in the design and execution of the project, and will be of great benefit to the project manager when the time comes to implement the project.

Finding a project manager with the necessary skills to head the task force can be a difficult problem for an organisation that has no experience of projects. There are several solutions. One is to train an existing member of staff, which can work well if time allows. Another is to appoint a project manager on a temporary staff contract basis. A third option is to ask an external consultant to manage the project.

Case example 2: a programme that mixes projects for external customers with one or more internal projects

In the previous section, the introduction of a management change project into a organisation with no previous project experience was discussed. This section examines how the organisation of an organisation that regularly carries out projects for paying customers might be adapted to include one or more management change projects.

Figure 8 illustrates two alternative possibilities, in which the contracting organisation carries out its revenue-earning projects in either a matrix or a team organisation. Assume that each of the two companies depicted in Figure 8 has a similar project workload and that each is currently conducting two unrelated management change projects.

One point to make clear at once is that every management change project is so different in character from commercial projects that it is unlikely that any of the contractor's existing project managers would easily be able to take command of one without further training. The typical project managers in a contracting organisation are principally technically orientated. If they are particularly good at their jobs, they might also have a working knowledge of financial accounts and 'people issues'. But the requirement for a management change project manager is different. He or she is going to have to manage the project with the intention of realising financial benefits for the organisation in the longer-term future, and that can mean a protracted, often difficult period during which 'people issues' and monitoring of the organisation's financial performance become extremely important. A good management change project manager will understand the need to gain the acceptance of staff in all the departments that are going to be effected by the change, upon whom the ultimate success of the project will depend and will work closely with the organisation's financial managers.

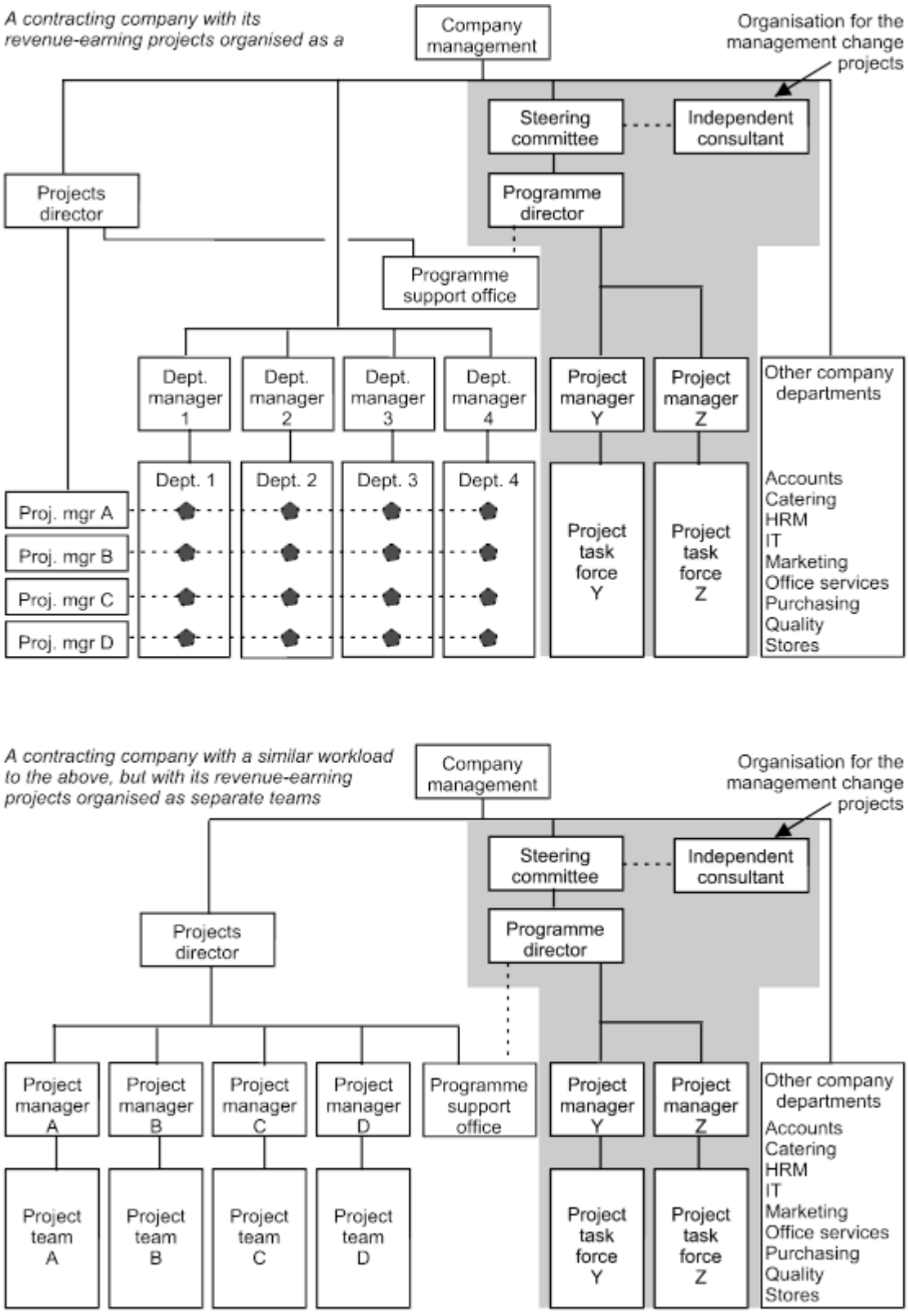

Figure 8 Two of the many possible programme organisations in a contracting company

Thus, the organisational solution should be one that separates management change projects from the regular progression of commercial projects and places them under a different management structure. This has been done in both the organisation structures shown in Figure 8.

A steering committee reports to the main board. It is authorised to make strategic decisions, liaising with external consultants and deciding the fate of every request for a project change (project change control is featured in a later section of this document).

The programme director is an appointment that only becomes necessary when there is more than one internal management change project. The role is similar to that of the projects director, but confined to the internal change projects programme. In some organisations the roles of project director and programme director are combined (one person doing both jobs).

The programme support office (PSO)

Whether or not the programme consists entirely of commercial projects, of management change projects only, or a mix of the two, it makes great sense to establish a programme support office. Even though the fundamental character differences between external commercial projects and internal management change projects prompt the establishment of two different project management groups, those differences do not preclude setting up one support office to serve all kinds of projects and their managers. Some companies use the alternative name 'project services' to describe their programme support office.

A programme support office needs its own supervisor or manager, who might be given the title 'project services manager'. A typical support office will combine the basic functions of cost estimating, critical path planning and task progressing, but a competent office can do much more. Here is a summary of the tasks that a programme support office could be asked to undertake:

- estimating the costs of new work or proposals
- registering newly authorised projects and allocating their serial numbers
- guiding project planning meetings (under the chairmanship of the relevant project managers)
- establishing and keeping up to date a computer-based model of the organisation's project workload (using a process called 'multi-project resource scheduling' that will be described later)
- issuing recommended task work-to lists to departmental managers
- managing the project management software and protecting its system and files from corruption
- running occasional 'what if' scheduling for senior management to test the possible impact of new work
- calculating estimates of future manpower needs that will help senior management and the HRM department to plan for changes (up or down) in staffing levels.
- project cost reporting and cost control
- change control administration, including maintaining a change log for each project
- contract administration, or at least that part of the process which requires constant updating of project budgets and client billings to keep pace with authorised changes in project scope or content
- risk management administration, including maintaining the risk log (the programme support office can be one 'home' for a risk manage)r
- compiling earned value reports for projects
- liaising with external sub-contractors, especially for design agencies
- and, as all the best advertisements say, much more

A project or programme support office can be expensive to set up and staff because although some of its members will need only basic clerical skills, most must be people with professional qualifications and experience. But the function can be justified and enthusiastically recommended for project organisations from medium size upwards. Figure 8 showed two possible organisational arrangements.

There are companies that run programmes in which some or all of the constituent projects are too small to justify their own project managers. One option is to appoint project managers who will each be expected to manage several small projects simultaneously. However, a competent programme support office can often undertake the junior project management roles of issuing work instructions, then measuring and reporting the resulting performance.

In many respects, a programme support office can be considered as just another specialist functional department in the organisation. Grouping all those related talents in one department is more efficient in terms of staff numbers and retained knowledge and experience than spreading its support work over the other functional departments and project teams. Above all, just as the computer database can store and process information across the programme of projects, so can the support office to earn respect as a human information hub.

There are several publications that describe the programme support role. These include Marsh's two books (1999) and Miranda (2003).

Project procurement and supply chain organisation

None of the organisation descriptions given so far has given sufficient prominence to the vital role played by the procurement and supply chain functions. That omission must now be redressed. This section describes an organisation structure known as a contract matrix, but the arguments given here for the procurement and supply chain functions apply equally to all other kinds of project or programme organisation.

Principles of contract matrix organisation structures

Figure 9 shows a contract matrix project organisation that is often used by contracting companies in the construction and civil engineering industries. Our example is loosely based on the organisation that was used by a large international mining group. Although our simple organogram cannot show all the complex command and communication links that would operate in practice, it does recognise the procurement roles.

The principal feature of a contract matrix is that the project owner or client (who has no direct experience of managing large construction projects) engages a contracting organisation that has considerable experience in undertaking construction projects. There are many possible arrangements but in our example the managing contractor carries out detailed project design in its headquarters offices (referred to as the home office to distinguish it from the site organisations). The managing contractor undertakes and manages all the project work on behalf of the owner, including all purchasing and the provision of the construction site team. Some managing contractors employ direct construction labour, and others, as here, rely more heavily on sub-contractors.

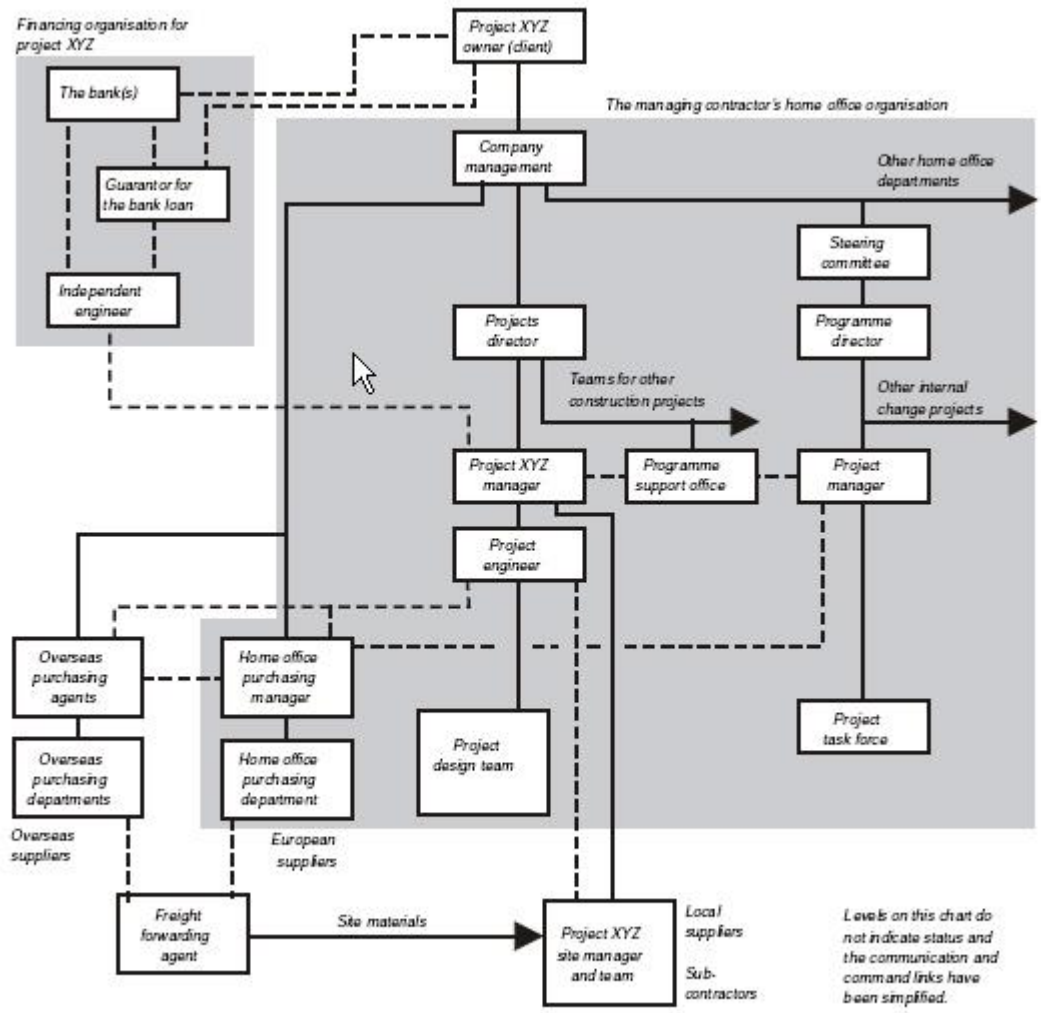

Figure 9 Part of a team-based programme organisation structure for a managing contractor

The managing contractor's home office could be organised as a matrix or as a number of separate project teams. Figure 9 shows the project team option (partly because it was simpler to draw!) and assumes that there would be a separate team for every project in progress. However, matrix organisations, similar to that shown in the upper half of Figure 8 are very commonly used.

It is probable that a large contracting organisation would also be carrying out one or more internal management change projects. That condition is indicated in the extreme right-hand portion of Figure 9.

The project financing organisation

There are many possible ways of financing a large project or programme, which can range from using existing capital reserves, through selling or mortgaging property assets (for example in sale and lease-back deals) to raising more capital through an issue of new shares. In the example shown in Figure 9, the owner of project XYZ has made a financing agreement with a bank, so that the bank will initially pay all valid claims for payment from the managing contractor. The bank requires insurance to protect the loan capital should the project fail. That

insurance has been provided by an external guarantor, to whom the project owner must pay a premium. For overseas projects carried out by UK companies the Export Credits Guarantee Department (a UK Government department) might act as guarantor (visit http://www.ecgd.gov.uk/).

Both the bank and guarantor will need to be convinced that the contractor's payment claims are valid. Because neither of those two bodies will have any technical project experience, that is usually done by appointing an independent engineer who will examine the progress made and certify every justifiable contractor's invoice.

Purchasing agents

The contractor's home office includes a purchasing department, and the manager of that department (operating through one or more buyers on the department's staff) represents the contractor in all purchase contracts and is thus a purchasing agent for the complete programme of projects.

However, when a contractor buys equipment and materials from overseas suppliers, it makes sense to appoint a purchasing agent in each country, or at least each continent, where such purchases are regularly made. A local purchasing agent will have first-hand knowledge of the commercial and technical regulations that apply in the region and can also be helpful in advising about local transport facilities. For example, one purchasing agent prevented an expensive mistake by pointing out to a contractor that the local rail tunnels had unusually small radii, so that long-load deliveries would have to be sent by road.

In another case, the local agent was able to warn a managing contractor of a special dockside security problem. Local shantytown dwellers, always keeping a keen lookout for building materials for their own 'construction projects', were apt to visit during the wee small hours and remove timber from packing cases. Thus expensive project equipment was left on the quays with no protection from the elements.

Overseas purchasing agents can repay their fees many times over in time and money saved on projects. As well as feeding the home office purchasing agent with vendor rating data, and in helping with supplier shortlists, local agents either employ, or can engage, inspecting and expediting engineers who can visit suppliers' premises to make progress and quality checks, and to witness crucial equipment tests.

Coordinating the purchases made by different agents

It is important that procurement over the whole programme is coordinated centrally, so that goods common to more than one project are identified. Then it is often possible to combine those purchases to achieve economies of scale. The coordination process must be directed by the home office purchasing manager, so that purchasing power for commonly ordered items is not diluted by spreading it over one or more agents.

The home based agent must also have systems in place that, while appraising him or her of all purchases in the group, prevent confusion over who has responsibility for placing particular orders. Such confusion can lead to duplicated orders or, possibly worse, goods not being ordered at all.

Multiple project managers

An interesting point to note about project purchasing is that the manufacture of every item of high cost bought-in equipment will probably be seen and managed by its supplier as a project within the main project. Thus many suppliers and sub-contractors will appoint their own project managers to work on their portions of a large project. A contract matrix organisation usually contains a number of project managers in addition to the main project manager.

Purchasing agents must ensure that the internal planning and control methods used by those suppliers and sub-contractors are adequate to ensure timely delivery of work that is fit for purpose.

Freight forwarding agent

International movements of freight bring a panoply of specialised procedures into play that would confuse the average engineer, and even some buyers. These procedures include such mysteries as export invoices (which some nations demand are printed in an astonishing number of copies on their own forms) and international letters of credit. Port and customs' duties are also important 'Failure to pay them, or to observe other local procedures, can result in goods being held up in customs sheds for long periods.

Every wise contractor operating internationally will appoint a freight forwarder organisation to advise on all transport issues and to oversee the transit of all goods in the programme. The experience and wisdom of a good freight forwarder complements that of local purchasing agents. Every reputable freight forwarder has access to a worldwide organisation with good communications that allows every consignment to be tracked throughout all stages of its journey.

The freight forwarder will know how to avoid the use of ports that are experiencing temporary congestion and delays, or he or she will route goods to avoid national border posts where the local customs officers are unreasonably officious.

Freight forwarders also help to cut transit costs by consolidating to optimise container loads – ensuring that half-empty containers are not shipped.

Site purchasing organisations

All but the smallest construction site will have its own materials controller, and on the larger sites the controller will be empowered to make local purchases.

A site materials controller, and his or her team, should be regarded in just the same way as the goods inwards and stores functions in a home office. The site materials controller is responsible for goods inwards checks, secure and safe storage, safe materials handling procedures, and for both routine reporting and exception reporting back to the purchasing agents. On larger sites the materials controller will also have some limited local purchasing authority.

Partnerships between purchasing agents and technical staff

Prudent people know that purchase contract negotiations are more like to be trouble-free when they are conducted on a partnership (win-win) basis. Of course competitive purchasing, using invitations to tender and sealed bid procedures must be in place for every order of significant cost. None the less, partnerships are intrinsically more productive and free from risk than confrontations.

Choice of the successful bidder in every case must be a joint decision between the buyer and the project engineer, the former to oversee the commercial aspects and the latter to decide on the expected technical or quality performance. So, here is another form of purchasing partnership, this time between each buyer and the relevant engineer.

Unfortunately engineers often undervalue the work of purchasing organisations, believing that their only purpose is to issue purchase orders printed on standard forms. Conversely, buyers might have their own preferred sources of supply based on solely on commercial reasons, but the engineers might believe some of those suppliers to be less than technically perfect.

Project managers and engineers must not ignore the professional support available from their purchasing departments. Even the most brilliant engineer will probably be unfamiliar with the practices and terminology used in purchasing and supply chain circles and that unfamiliarity could lead to some expensive mistakes. The average engineer will certainly know what an FAQ is, but failure to recognise FAS as an Incoterm could lead to some serious cost and risk implications. Every engineer knows the relatively small difference between a metric tonne and an imperial ton. Not knowing the potentially far greater difference between either of these and a shipping ton could provide an expensive mistake when shipping a few tonnes of bulky but feather-light goods.

Engineers must often talk to suppliers during the bidding phase for an order. They need to do that to resolve technical questions and, sometimes, to agree mutually beneficial changes to purchase specifications. However, there is always the risk that an engineer will breach the accepted rules for sealed order bidding if such discussions give one supplier an unfair advantage over another. Another serious and more common risk is that an engineer will unwittingly (or even purposely) commit his or her organisation to a verbal contract during telephone discussions or to a written contract where emails are involved. This pre-empts the purchasing process and, possibly, sealing a less-than-perfect contract. Roylance (2006) calls this unofficial activity ‘rogue purchasing’.

Roylance sensibly declares that, just as a purchasing department needs to negotiate with external suppliers, so it must act as its own internal marketing department, ‘selling’ the advantages of its services to the contractor’s engineering staff (and to senior management).

Scheduling resources part 1: introduction

Resource scheduling is a subject that is poorly served in the literature, probably because it is so complex. The ideal goal of resource scheduling is to convert the intended project work plans into schedules that use only the resources that are available (or that can easily be made available) and to arrange that the daily requirement for each kind of resource is as smooth as possible, with no significant peaks (overloads) or troughs (implying idle resources).

The technicalities of the process depend to some extent upon which software package is used. Scheduling of any project can involve complexities. These include different calendars, especially for companies that mix normal day working with shift working, or conduct international projects where some sub-contractors and workers observe different holidays. There are also questions such as to whether or not any task may be interrupted to allow resources to be diverted temporarily to other more critical tasks. Many of these issues are discussed in some detail in Lock (2007), and it is not appropriate to go into greater detail here. However, it is possible to give some general advice. Most of the following advice refers to commercial and industrial projects. But common resources diverted to work on internal change projects should be included in the same multi-project scheduling process.

The first question that any project or programme manager should ask is 'Do we need to carry out any resource scheduling at all?' The only case where that question will generate a negative answer is for a project or programme of projects where absolutely every task is let out to sub-contractors. Resource scheduling is still necessary, but under those circumstances it is the sub-contractors who must do it.

Another basic question is 'What do we mean by resources?' In theory any resource that can be quantified in terms of a name and simple usage quantity can be scheduled (bulk materials, cash, machining and test facilities and people with special skills, for example). Some resources are difficult to describe in simple one-dimensional units. For example, assembly space is three-dimensional and the shape of the space is sometimes important. However, when most project managers talk about resource scheduling they mean scheduling people with specific skills or trades. That is the aspect of resource scheduling which will be discussed here. Once the process has been mastered, it requires only common sense to extend it to scheduling the other kinds of resources (and to multiple concurrent projects).

Following the dictum that it is better to learn to walk before trying to run, this section must first examine some of the steps for scheduling a single project. Then the argument can progress to scheduling resources for a programme.

Priority rules

Resource scheduling involves deciding which project tasks should claim priority for the allocation of scarce resources. Establishing that answer begins by ensuring that every project is planned by a suitably detailed critical path network. Network time analysis will reveal how much float each task possesses. Tasks with no float are critical and have first claim on resources. The priority status of other tasks is inversely proportional to their remaining float. (Remaining float is the amount of total float that remains for a task after its start, or progress has been delayed for any reason, including intentional delay during resource scheduling). Most project management textbooks describe the critical path method fairly well. Gordon and Lockyer (2005) is one text that has enjoyed popularity over several editions and Devaux (1999) abounds with common sense.

Some essential resource scheduling principles are displayed in Figure 10. Imagine that each section of Figure 10 shows the same fragment of a bar chart (Gantt chart) for a project, extracted from the bar chart for the whole project. Further, please remember that the original whole bar chart (which might contain hundreds of tasks) was obtained by conversion from a project network diagram after time analysis. All competent project management software readily produces such conversions.

Each of the three sections of Figure 10 shows the entire project plastering tasks required for a small project. In the top part of Figure 10, the planner has taken no account of resources but has simply placed each task at its earliest possible time indicated by the network time analysis. The result is known as resource aggregation. That approach, although commonly practised by project managers, almost always leads to an impossible resource usage pattern that contains both overloads and idle periods. In the example of Figure 10, the project contractor has one only plasterer on the payroll but the aggregation schedule requires two on the first day, three for each of the next two days, before falling back to the preferred limit of one plasterer. Clearly that work pattern is far from ideal.

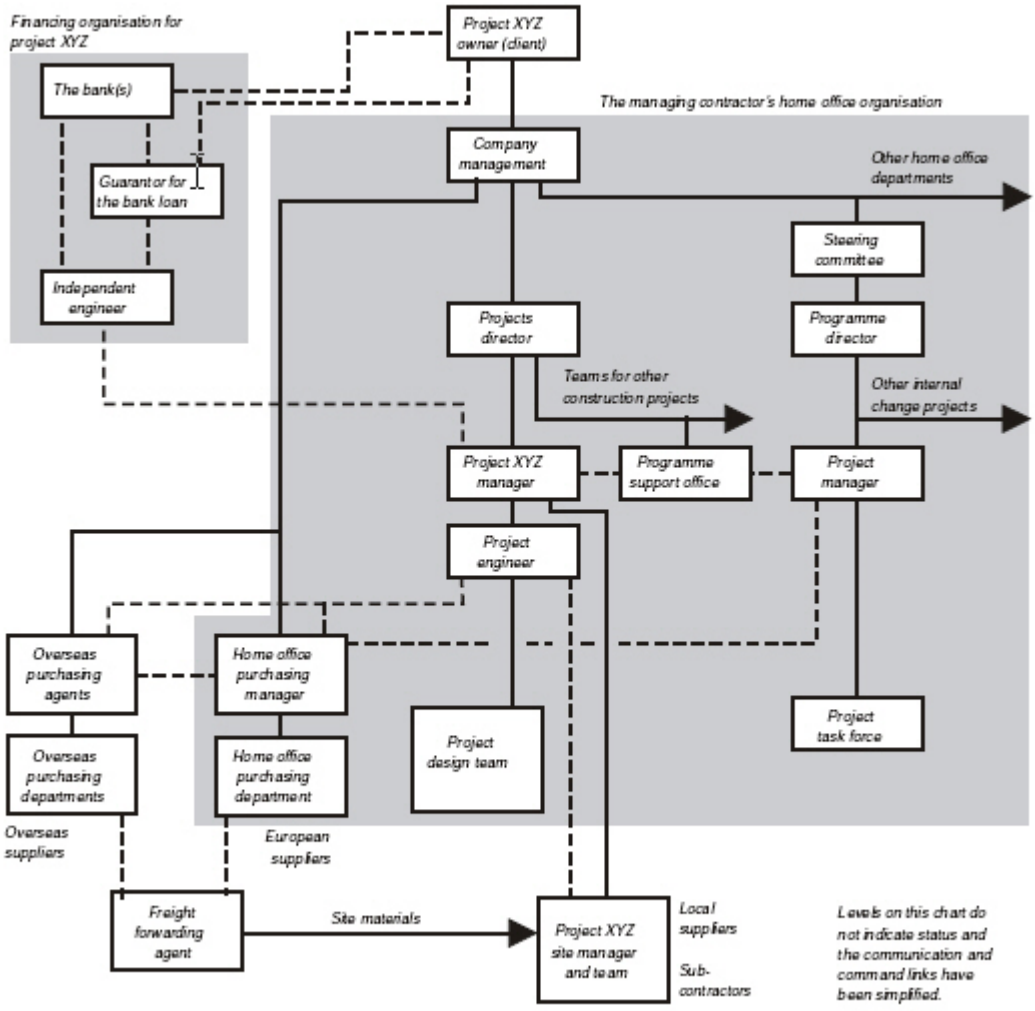

Figure 9 Part of a team-based programme organisation structure for a managing contractor

Four of the five tasks shown have some total float, and those tasks could be delayed slightly without delaying project completion. But task 130 is critical and must be carried out as early as possible. That information will allow the planner to schedule some tasks a little later to smooth out the peaks in the resource usage pattern.

In the middle portion of Figure 10 the planner has delayed some tasks until the resource requirement never exceeds the total available (which is one plasterer). That has produced a resource-limited schedule. Now the resource usage requirement never exceeds one plasterer,

but that has delayed task 120 for two weeks beyond its total float, which indicates that the entire project will also run two weeks late.

If the planned delay to a project caused by a resource-limited schedule is unacceptable, a time-limited schedule can be calculated, as shown in the bottom part of Figure 10. Now the project will need two plasterers, but their usage pattern is far better than that shown in the original resource aggregation. In the time-limited case, no task has been delayed beyond its remaining float.

At one time small projects could be scheduled in this way using adjustable wall-mounted charts, using some mechanical solution such as plug-in plastic strips or magnetic bars on a steel board. Now there is plenty of software available that can schedule not only one project, but all the projects comprising a programme. All good software will allow the planner to direct whether a resource schedule is to be a simple aggregation, resource-limited or time-limited.

There are other options, such as the use of threshold resources which can be deployed to soak up overloads. Overtime or bought-in temporary staff could provide threshold resources. These complexities will not be discussed here but they are explained in Lock (2007).

Scheduling resources part 2: summary of the data input process

The following lists show data that might typically be required before the computer can carry out resource scheduling and provide useful reports (such as work-to lists). These are for general illustration and will not apply identically to every brand of project management software.

Global data for the project contractor

- Organisation name
- Security access levels (often numbered from 1 to 9, the top level allowing access to make system changes and the lowest level read-only of low-confidentiality information)
- Departmental codes (each code identifies a functional department and its manager, so that data can be filtered later to allow each manager to get reports containing only the tasks for which he or she is directly responsible)
- Default calendar (the calendar driving all scheduling, based on the normal working week with all public and organisation-wide holidays identified as non-working days)
- One or more special calendars (each to cover such exceptions as shift-working, departments allowed to work overtime, and overseas parts of the organisation which observe different working hours and holidays)
- A code and name for each type of resource to be scheduled
- A number specifying the amount of each resource normal available for project work between given period start and finish dates (there is a note on this in the following main section)
- A cost rate for each resource, related to each time unit used in scheduling (for example, dollars per day per unit person), again valid between the same period start and finish dates
- Different resources availability levels for different periods (this allows for future forecast changes in resource levels)
- Different resource cost rates for different periods (which allows for cost inflation and wage awards in the future).

Data required for each project

- Project code ID and project name
- Name and department code for the project manager
- Project start date
- Required project finish date

Data required for each task

The following list is based upon rate-constant resource usage. See Lock (2007) for other options.

- Task ID code from the critical path network diagram
- Task name (usually abbreviated to fit in subsequent narrow report columns)
- Project code, which identifies each task with its project. Ideally this code should be a prefix to the task ID code. Some software can prefix these codes automatically. Some talented planners will use the WBS code.
- Estimated task duration (based on using the preferred amount of resources each day)
- The resource code and quantity for each type of resource (if any) required for the task
- A total estimated task cost (useful tasks such as materials purchases)
- Whether or not the task is a milestone or key task (project start and finish tasks will always be milestones)
- Target or fixed-schedule start or finish date for the task, (best avoided if possible, because these injected fixed dates interfere with optimum scheduling)
- Whether or not a task that used resources is splittable or non-splittable (non-splittable is the usual default condition: splittable tasks may be interrupted to divert their resources temporarily to other, more urgent tasks). Task splitting is not recommended because it is disruptive for the resources effected and can damage motivation
- Either the ID code of the preceding task(s) or of the succeeding task(s), so that the computer can trace all the paths through the network diagram.

Data required for each multi-project schedule calculation

- Time-now (which is the datum from which all progress information and new schedules will be calculated
- Report customisation, which essentially means specifying the column headings of each report
- Filter instructions for each report, which dictates what each report shall include or exclude. This is most useful for compiling departmental work-to lists, for producing exception lists (described in the progress control section of this document) and for milestone reports for higher management.
- Sorting instructions for each report (for example, sorting all tasks in a work-to list in ascending order of their scheduled start dates).

Scheduling resources part 3: practical application to multiple projects

Avoiding over-complication

The previous paragraphs contained a considerable amount of detail, and even that was not complete. In any organisation conducting a programme of projects, there will undoubtedly be thousands of tasks to schedule, and all significant tasks must be included in the software

model. However, there are some common sense rules that can make the lives of newcomers to multi-project resource scheduling more enjoyable and rewarding. Failure to observe the common sense rules given in the following paragraphs can clog up the process and choke it to death.

Dealing with ad hoc and unforeseeable tasks that cannot be planned in advance

There will always be a myriad of small, unexpected, jobs that crop up in most departments. These can include everything from re-work and corrections to tasks (in design this is called after-issue work), answering queries from many sources, and so on. These odd jobs will divert staff who would normally be expected to be working on project tasks.

Coupled with these diversions are the absences of individuals because of training courses, sickness, annual holidays, compassionate leave and so on. All of these absences reduce the numbers of staff available for new project work in each resource category.

Rather than try to deal with these complexities in their awful detail, it is simply necessary only to allow for a 'sludge factor' when 'telling' the computer the available amount of each resource. Suppose that you have 50 mechanical design engineers on the payroll. It would be an unwise planning engineer who declared 50 of this resource type to be available to the multi-project model. This writer has used a sludge factor of 15 per cent to cover the sludge. Thus, if you have a department of 50 design engineers, tell the computer that you have 43. Trial and error might eventually suggest a different sludge factor, but 15 per cent is a good number to begin with, and that should be applied to every resource type.

Choosing which resources to schedule

All good software (and even bad software) will allow well over 100 different resource categories to be specified. But it will probably be necessary to schedule only a few key resource types.

One multi-project model for an organisation of 600 employees conducting many heavy engineering design and manufacturing tasks was operated accurately and successfully with only six of the many resource categories being scheduled. Those categories were:

- Mechanical design engineers
- Drawing office
- Checkers
- Light machining
- Heavy machining
- Assembly

Thus many of the thousands of tasks in the multi-project model were shown as needing no resources. The rationale behind this apparent carelessness was as follows:

1. If the work of the mechanical design engineers was scheduled in a smooth flow, the associated work by other engineers in designing the controls and lubrication would automatically follow the smooth flow.
2. It was not necessary to schedule every manufacturing task, but only to ensure that work entered the factory machine shops as a steady flow of engineering drawings. The day-to-day scheduling in the factory was taken over by the separate production control system, but the

multi-project model did give the production control manager required start and finish dates for each sub-assembly.

A similarly simplified approach should be sought for any multi-project model, regardless of the industry sector in which the organisation operates.

Scheduling down to the last five minutes?

An enlightened planning engineer, or project manager, who is attempting to keep the multi-project scheduling as simple as possible, will undoubtedly meet with opposition from other managers and supervisors, who feel that every minute of every person's time should be accounted for and scheduled.

One difficulty arises when a person of a particular skill works on several tasks at the same time. Buying clerks fall into this category. However, if the design engineers who are writing purchase specifications are scheduled, then the buying clerks will receive their tasks at a smooth rate and their daily tasks probably need not be scheduled. Of course, the procurement tasks will appear on the network and will contribute to the critical path, but they need not be shown as needing human resources.

If it is absolutely unavoidable, and the time of people such as buying clerks does have to be scheduled, there at least two possible methods:

1. Use decimal amounts for the amount of resource needed for a task
2. If the software will not accept decimal quantities, multiply both the numbers available and the numbers needed by 10. If cost rates have been specified, these will then have to be divided by 10 to produce the correct figures in cost reports.

Some software (including Microsoft Project) is very versatile and will allow hours to be mixed with the days or other units used for task durations. However, that approach can lead to some very complicated output reports, needing very wide columns to accommodate times given in days and hours. It is best to keep all duration units the same throughout the whole schedule.

A good argument for fending off those who try to over-complicate the scheduling process is to remind them that every schedule is based only upon estimated times, and those times will never be accurate. All that the schedule will do is to create some order where chaos would otherwise have reigned. However, when the multi-project model is large, the errors tend to cancel each other which leads to working schedules that are entirely practicable.

Setting priorities for the different projects in the multi-project model

Here is a recapitulation of how a sensibly constructed multi-project model will deal with priorities. Every task in the model, no matter to which project it belongs, will have its own amount of float (zero for critical activities and negative for activities running late). In every case, that float pertains to the required finish date as specified for the end task in the project's network diagram. Thus, all the float throughout the system, and therefore the measure of priority for every task is driven by the target finish dates for all the individual projects in the model. This means that all project priorities are automatically observed.

Some higher managers will be difficult to convince and there will always be those who feel that they must ask for more priority to be put on a particular project. But those senior people must be discouraged because artificial dabbling with individual task or project priorities will undermine the programme schedule and lead to poor resource allocations. This writer has seen very significant cost reductions and dramatically improved project deliveries as a result of introducing multi-project scheduling. If those kinds of results can be shown to the senior managers, then perhaps they will learn to lie back and let the computer take the scheduling strain.

Work-to lists

By far the most useful reports obtained from multi-project resource scheduling are the departmental work-to lists. The example shown includes fictitious data but is based on customised reports that have proved invaluable in practice. Each departmental manager is presented with a list of all tasks scheduled to take place in his or her department. Ideally the tasks should start and finish on their scheduled dates, because these are the dates that the computer has calculated for the smoothest allocation of resources. The earliest possible start date from time analysis is also given for each task in case resources become available unexpectedly, allowing a task to begin before its scheduled date. The latest finish for each task is the day when the entire task's total float would be used up. Figure 11 shows the ideal format for a work-to list.

WORK-TO LIST ALL PROJECTS Time-now : 03Sep09

Department: 02 Engineering Dept manager: I Drewitt

Sub proj.	Task ID	WBS code	Task description	Dur days	Earliest start	Scheduled. start	Scheduled finish	Latest finish	Total float	Lab cost	Resources	
23	23901	23023-10	Fixture layout	10	03Sep09	03Sep09	13Sep09	20Sep09	5	2000	1E	
26	26003	26003-00	Machine concept	15	03Sep09	03Sep09	20Sep09	20Sep09	0	3000	1E	
23	23402	23023-64	Pre-issue check drill head	1	03Sep09	03Sep09	03Sep09	16Sep09	10	350	1E	1C
23	23450	23030-05	Purchase spec gearbox	2	03Sep09	03Sep09	04Sep09	13Sep09	8	400	1E	
23	23807	23001-02	Detail machine assembly	10	03Sep09	09Sep09	20Sep09	20Sep09	5	1000	1D	
23	23403	23023-64	Issue drawings drill head	1	04Sep09	04Sep09	04Sep09	17Sep09	10	0		

Figure 11 Fragment from an ideally customised work-to list

Preserving the integrity of the multi-project model

It is very easy to introduce errors into the multi-project model, or to corrupt it by entering one or more invalid pieces of control data (for example, by specifying an incorrect resource availability level or confusing dollars and pounds sterling when specifying a cost). Inexpert interference could change basic parameters, such as the calendars used.

The effect of such errors will become more serious as the number of mistakes accumulates and their combined effect grows with time. Remember that a programme, unlike a project, has infinite life because as projects are finished new projects are added. Thus the multi-project model is unlike the schedule for a single project because it, too, has infinite life. It takes enormous skill and effort to re-establish a multi-project model that has been corrupted.

The scope for making mistakes is so great that the multi-project model must be placed in the hands of experts who are very familiar with all aspects of critical path networks and who have special training and experience in the use of the relevant software package. They will know what checks to apply and how to avoid the introduction of errors. A good place for those experts is in the programme support office. That arrangement is shown in Figure 12.

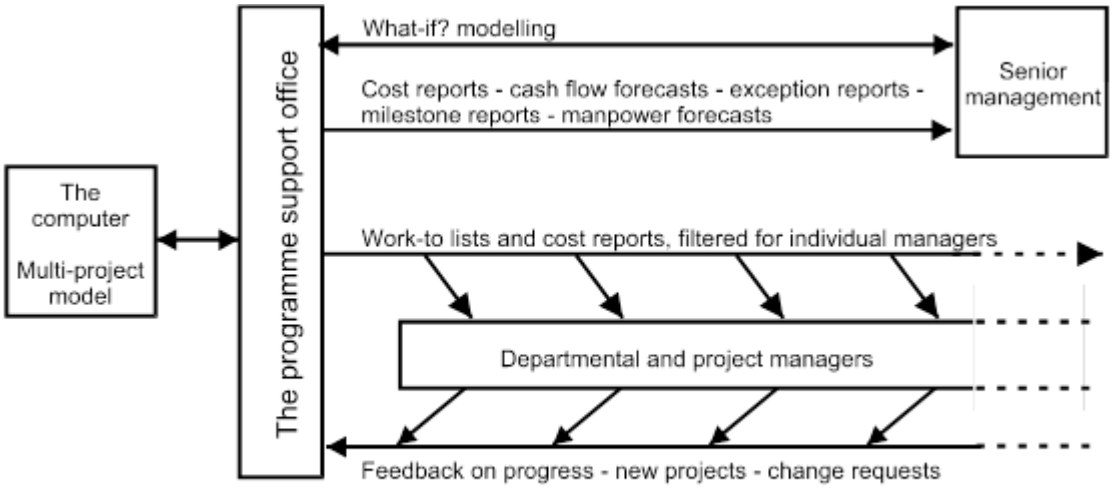

Figure 12 A programme support office as guardian of the multi-project model

Although multi-project scheduling requires expert operators, it need not be expensive or require more than a few planning engineers. Very large programmes can be controlled by a surprisingly few expert planners, but there must be at least one other member of staff trained to take over this role as a back-up reserve.

The ideal planner will be a person of high intelligence, the kind of person who enjoys solving puzzles. Such people learn to develop and exploit advanced short-cut methods (such as standard modular networks) that will save a great deal of money, and have an error-free schedule ready for every new project within a few hours rather than weeks.

A method for allowing project managers to have hands-on access to the multi-project model

Although this section has assumed (and by implication recommended) the need for a managed and protected multi-project model, there is another approach for organisations that want their project managers to be separately and individually free to prepare run their own planning and control. In that arrangement, each manager can produce schedules using less expensive software such as Microsoft Project, but a server can carry a database that will gather in all these plans and create a programme model. Geoff Reiss (1995 and 2006) is an expert who has pioneered that approach and he runs a organisation which has developed software to support this method.

Buying and installing suitable software

There is an abundance of software from which to choose for the scheduling and management of single projects. Some of those systems have a good capability also for dealing with multiple concurrent projects or a programme. In recent times a number of systems have also become available that can assist with portfolio management. However, some suppliers make extravagant claims for their products and the software will disappoint and prove to be an expensive mistake if the wrong choice of system has been made.

When software that fails to live up to expectations is cheap, it might be argued that not much money was wasted on its purchase and all we need to do is try again with a different product. However, in programme management many people will be effected by the software and will be expected to use it at one level or another. That implementation process is expensive. Worse, if it fails, the new attempt will be beset with the problems caused by the general apathy and distrust of those who, having seen one failure, will confidently expect another. A perfect example of a self-fulfilling prophecy.

Suppose that you intend setting up a system for multi-project resource scheduling of all the projects in a programme that contains over 100 projects (one of this writer's clients had over 150 concurrent projects). After some research, you might decide that the final operating model will contain perhaps more than 40-000 tasks (spread over the 100+ projects). So, the software must be able to calculate common programme resources over a global network containing that number of projects and tasks. Now ask each potential software supplier how many tasks the software can handle and you will probably receive the reassuring answer, 'The maximum permissible number of tasks is limited only by the available computer memory'. But, now ask the different question, 'How many characters can a task ID contain and can they be alphanumeric?' If you get the answer 'Up to 9999, and they must be numeric' you have learned the true capacity of the system.

Many software systems call the whole programme model 'the project', so that each real project is described in the software as a sub-project. That causes no difficulties unless the number of 'sub-projects' the system can handle is below the maximum number of real projects that you can foresee in your future programmes.

There are essential differences in the expectations that particular project or programme managers have for their project management software. There are those who employ their systems principally for simple task sequencing and for collecting and analysing performance data and presenting it in a form that is useful and attractive to senior managers. Most of those senior managers will appreciate well-presented and visually effective reports, employing such methods as bar charts, pie charts and RAG progress reporting. (For those unfamiliar with this term, RAG reporting refers to pictures of red, amber or green traffic lights alongside various pieces of data to identify each reported result as bad, indifferent or good.) These kinds of reports can be very useful in helping managers to make decisions.

When the software is used also to schedule costs and resources and produce departmental work-to lists of all the tasks in a programme, it is actually making important management decisions itself. These decisions follow the processing of volumes of data that are far too great for the human brain to contemplate, and can yield schedules that, if correctly observed, will directly promote efficient working and save time and money.

The purchase of software should be conducted using the same principles and degree of investigative care that one would apply for any expensive purchase. A few names stand out from many others as being more reliable (yet still affordable) than others in this field. These include, for example, 4c Systems, Open Plan and Primavera. Lock (2007) provides a specification checklist and general advice on the acquisition of project management software for multi-project scheduling. The journal Project Manager Today occasionally publishes comparative tables for a wide range of software that can act as a starting point (but only a starting point) for identifying potential software suppliers.

When the system is first installed, its implementation must be taken very seriously. Key staff, probably from the programme support office, must be allowed time for the essential specialist training that only the software supplier can provide. The system will fail dismally if senior managers (and, for that matter, project managers) frustrate the efforts of the newly trained experts by allowing individual departmental managers and other project workers to go their own ways and ignore the essential system communication requirements.

Controlling and correcting work in progress

The control loop approach

Every electronic engineer knows the theory of a control loop in which a signal is fed to a system, and the system contains monitoring circuits that can detect distortion and feedback correction signals that remove most of the errors. A similar principle can be applied in project management to keep tasks on track and correct errors. The concept is illustrated in Figure 13 and, because of the electronic analogy; this common approach to task management has been called cybernetic control.

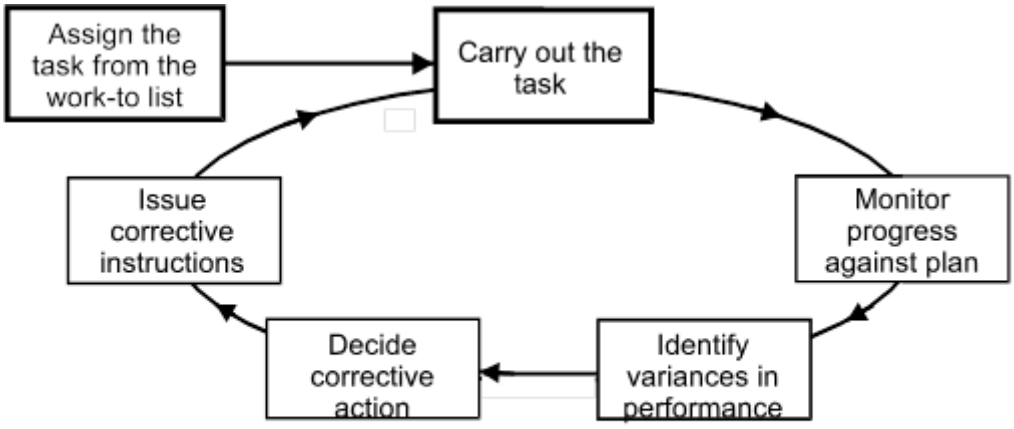

Figure 13 A control loop with corrective feedback

The theory in the project management application is simple but important and can be applied to tasks within any kind of project up to its initial completion. However, this theory is often too mechanistic for application to tasks in management change projects during their implementation periods. Here the attitudes and motivations of people are the dominant factors in success or failure in the benefits realisation process.

The value of the work-to lists described in the previous section becomes apparent when considering control loop task progressing. On any day, every manager and supervisor knows which tasks should be starting, in progress, or ending within their departments or groups. When a new task is due to start, the manager responsible decides which person is best able to carry out the work, issues instructions to define the task, and keeps an eye on the job for its quality and progress. If any deviation from plan is detected, the manager discusses the difficulties with the worker and corrective action is agreed and applied. In management parlance, these deviations from original plans or budgets are called exceptions or variances.

The principle of management by exception

Management by exception is the process of concentrating management attention on tasks that need action because they are either going wrong or are in imminent danger of doing so. Communication channels and reports highlight these exceptions in a process that is, not surprisingly, called exception reporting. Senior managers are screened from floods of routine data that need no action, but instead have thrust before them bleak warnings of things that need to be put right. Managers do not ordinarily receive reports of tasks that are going according to plan, except when the time comes to tell them that a project has been successfully completed.

A materials shortage list is exception reporting personified. Every competent purchasing manager knows the importance of clearing shortages as soon as possible so that idle time and task delays are kept to the absolute minimum. Shortage lists, unlike bills of material, parts lists and order status reports, do not contain every item delivery of materials or component needed for the project. They simply scream for help in getting shortages cleared as soon as possible, so that project delays (that waste money as well as time) are kept to an absolute minimum.

Time analysis data from critical path networks is invaluable. Tasks that are running late but which are still within their float times are exceptions. These can often be omitted from exception reports, provided that the managers and supervisors responsible are using all their persuasive and organisational powers to bring those tasks back into line (perhaps by allowing some overtime working). But critical tasks (tasks with zero or even negative float) require all stops to be pulled out to get them finished on time. Spending an extra £1,000 on a task to bring it back on time can often save far more than that amount in overall project costs. Remember that every project delay costs money, through the risk of idle labour time, and through the increased time for which the project will have to carry the organisation's overhead costs.

Corrective measures

For exceptionally urgent cases there is a process called immediate action orders. That process can cover all aspects of a task from design, through purchasing, and execution to final testing. It can be expensive but it produces dramatic results. The process is described in Lock (2007).

One extreme measure to contemplate when a whole project appears to be running late, and out of control, is to create a task force that can drive the remaining tasks through to successful completion. There is no better motivator than a dedicated task force for driving urgent tasks through to success.

To create a task force, senior members of all the departments involved in the relevant project tasks are removed from their daily jobs (and from their desks) and are assigned to a temporarily appointed task force manager. These task force members should be picked at a level of seniority which allows them to commit their 'home' departments unequivocally to decisions made at task force meetings. A special office must be set aside which the task force can call its 'war room', where charts and drawings can be pinned to walls or left laid out on tables, and where the task force can meet whenever it needs to. The war room must be protected from the routine communications and affairs of everyday work, so that the task force members are not distracted by non-urgent interruptions.

Another important approach is to practise concurrency as often as possible. This means planning so that each task can start as soon as possible, not necessarily having to wait until its so-called preceding task is completely finished. This process is well known in the partnership that should exist between design engineers and buyers. Here the engineers will give the buyers advance notice of all long-lead items, as soon as the specifications are firm enough to allow orders or letters of intent to be issued. When as many tasks as possible in a plan are overlapped, the method is called fast tracking. It can shorten the total duration of a critical path network dramatically, although it will introduce an element of risk in the event that some early instructions have to be changed later as more facts become known.

Controlling changes to work in progress

No matter how well one attempts to define a project, it is a very rare project indeed that runs from authorisation to completion without any changes.

First, we must be clear about what is meant by 'a change'. If a designer tears up a drawing in a fit of rage and frustration and starts again because of a fundamental error, that is not a change because the drawings have not been issued, no other part of the project is effected (except perhaps through the delay caused) and neither the project specification nor the project scope have been effected.

A good definition of a change in this context is any action that would cause changed specifications, drawings or other documents to be reissued, where that would affect work in progress in other parts of the organisation, or the project scope.

Every organisation has to be aware of one danger that is specific to small, seemingly insignificant, changes. Whilst the foreseeable effect of a small change might seem to be trivial, the cumulative effect of several such changes can be more serious, even to the extent of expanding the scope of the project beyond that originally authorised (this unfortunate process is sometimes called 'scope creep').

Changes in projects for external customers

Changes can be categorised in several ways, the most important of which is whether or not the change has been requested by a paying customer. Customer-funded changes usually add revenue to the project, and the profit margin for work done under a contract variation can be higher than the margin for the whole project (because there are no competitors who have to be under-priced). Customer requests for changes usually have to be accepted, and will only be rejected (politely) if the contractor's engineers consider that they would introduce new risks for reliability or safety or in some other way jeopardise the project.

Changes can cause work in progress to be scrapped. For that reason, a change made later in the project life cycle will usually be very much more expensive and cause more disruption than the same change made before design starts, because the money invested in work in progress (sunk costs) always grows with time. Many companies impose a 'design freeze' or declare a state of 'stable design' when they feel that the investment in work in progress on a project has passed a critical point.

Changes originating internally have to be subjected to more rigorous scrutiny than those funded by customers. Clearly, if a serious design error has been found, or if changes are required to clear difficulties in manufacture or construction tasks, then the contractor has little option other than to make the change and accept the additional cost.

One new difficulty for modern project managers is that rapidly advancing technology can render designs 'old-fashioned' before the project has been completed. But changes that are classed as 'desirable' or 'nice to have' must be resisted because every change brings hidden risks or additional costs and project delays.

Every organisation that conducts projects should, therefore, have procedures in place for considering each change request. Many companies assemble a change committee (or change board), comprising a design authority, an inspecting or quality authority, and representatives of other departments likely to be effected by changes.

The control of changes can cause a considerable amount of administrative work to ensure that:

- Every change request is entered in a serially numbered log
- Every change request receives scrutiny for its effects on safety, reliability, progress and costs
- The change originator is informed of the change committee's decision
- The decision of the change committee is implemented
- Design drawings, specifications, and other documents, are suitably modified so that when the project is finished they record the true as-built condition
- Purchase order amendments are negotiated and issued for all active purchase contracts effected by the change
- Customers are correctly billed for all changes originated by them
- Authorised budgets are amended where appropriate.

Keeping track of the effect that changes have on the overall price of a project, and ensuring that they are billed to the customer, is part of a process called contract administration. That task and all other aspects of change administration are roles that a programme support office is ideally placed to carry out.

Change proposals for internal projects

Procedures for considering and implementing change proposals for internal management change projects are very similar to those just described for commercial and industrial projects. However, all changes to internal management change projects will be paid for by the contractor, because there is usually no external source of funds. With the relatively rare exception of changes intended to reduce project scope, these changes will always increase investment costs. Thus, such changes have to be considered against the original business plan for each project, and change authorisation must be at senior level.

As with change proposals for external projects, the programme support office is the ideal place from which to administer these changes, but the authorisation level should be not lower than the steering committee.

Cost control measures for commercial and industrial projects

Much has been written on the subject of cost control. However, most published material deals not with cost control but with cost analysis and reporting. The activities of cost and management accountants, although admirable and necessary, are not called historical costing for nothing.

Project and programme managers are not historians. Their primary interest must be directed towards controlling present and future costs. Therefore, this section (after dwelling briefly on cost collection and reporting methods) will summarise some of the actions that can actually keep project costs in check. We have to start from the precept that every project has a coded work breakdown structure, and that the best possible cost estimates have led to authorised budgets that overlay the WBS hierarchy. Those same cost estimates should also be arranged in an alternative fashion to provide departmental budgets.

Labour cost collection methods

Methods for collecting labour times are too well known to need detailed description here but, summarised, they depend either on timesheets or time-recorded job cards. In the context of project and programme management, the following shortlist should be noted:

- All recorded times must be checked by a supervisor and must be available for audit
- In cost-reimbursable contracts the times may have to be both audited and certified
- Checks must be in place to deter staff from 'losing' idle time by booking it to the most readily available project job number
- Many modern project software packages have timesheet facilities (but a famous software organisation once quoted £200 per annum per timesheet user in addition to the software purchase price, so buyer beware)
- The software should be programmed to recognise and reject attempted time bookings to closed account numbers.

Cost collection methods for purchased goods and services

Again, the traditional cost collection methods for project purchases are well known and do not need description here. However, there are important differences for the project manager because the earlier he or she receives cost information, the sooner he or she can compare purchasing costs against budgets and spot any exceptional trend. Summarised, the different cost collection methods for purchases are as follows:

1. Traditional job-costing methods based on costing stores issues against job numbers
2. Total costs of payments to suppliers and carriers against their invoices, collected by project numbers
3. The total costs of all purchase orders placed for each project.

The first of these methods is useful for providing historical records for use in comparative cost estimating for future projects. The second option has the advantage that it will include the

costs of freight, port dues and customs taxes but the figures will not be available until well after the event.

The third method, when used regularly at frequent and regular intervals, gives the project manager the earliest possible true cost data, at the time when the costs are committed. Thus adverse trends for the project can be spotted as early as possible. But this method depends on trust, close cooperation, and good communication between project and purchasing managers, because only the purchasing department can compile and issue these reports.

Controlling labour costs

Although this important subject could be discussed at very great length, its vital elements can be summarised in just one short sentence. Control progress and you will control labour costs. Managing progress will also go far in controlling indirect costs (overheads). The maxim 'Time is Money' is even more relevant in 21st century programme management than it was in 1748, when it was first used by Benjamin Franklin in his Advice to a Young Tradesman.

Control of purchased materials and equipment costs

Again the principle of cost control can be summarised in one sentence. Control costs before or when purchase contracts are made and avoid subsequent order amendments. Every competent purchasing manager will understand and follow the procedures needed to cement this rule. Once an over-budget contract is made, it is too bad. The damage has been done.

Delays caused by materials shortages are always expensive. In addition to delaying project tasks, they waste money by causing idle time, delaying the receipt of stage payments from the project owner, and by adding indirect costs to the project simply because a project that runs late will attract fixed costs for longer than planned. Efficient and pre-emptive expediting by the procurement function can do much to reduce the risk of materials shortages. The logistics function plays a major part in ensuring that the materials are placed at the point of use when, or before, they are needed. All this is part not only of progress control, but also of cost control.

Control of sub-contractors' costs

Sub-contractors in a programme can range from scaffolders to IT companies and discussion of their costs could double the length of this paper. However, there are a few general principles, which are not dissimilar to those for controlling the costs of materials.

Each sub-contract should be seen as a purchase contract and managed as a mini-project within the relevant main project. That means:

- Every sub-contract must be made by an authorised signatory
- The schedule of work to be performed and the rates to be paid must be clearly included
- Changes to sub-contracts should be avoided as far as possible
- Sub-contractors' work and project management methods must be monitored regularly for progress and quality
- Every sub-contract should be controlled by contract administration procedures similar to those used for the contracts made between the project customer and the contractor for each whole project (scaled down as appropriate)
- No claim for payment should be accepted without verifying that it is a true reflection of the work actually performed.

There is a special danger on construction projects that ad hoc requests made on site to sub-contractors will lead collectively to a considerable increase in the expected costs. 'Do you think while you are painting that wall, you could also go along here and do those railings for me?' or 'Hmmm, I think we need a couple more courses of bricks on that wall and some razor wire along the top – could you do that for us please?' On a large project there might be hundreds of such requests. The control method is to ask the sub-contractor for a day work sheet for every such change. Those day works must be authorised by the site manager and the sub-contractor's on-site manager. Then, when the project is ended and the days and months of final reckoning come, every additional claim for payment can be verified against its relevant day works sheet.

Maintaining valid cost budgets

The preferred method for establishing a project budget (and by extension the programme budget) is to begin by estimating the cost of each part of the work breakdown. Those estimates will 'roll-up' to give the net total project budget. They can also be rearranged to provide departmental budgets.

All good project cost estimators will also add some 'below-the-line' items. These are items that will add to the prime costs of the project in the event that certain new conditions will occur. The principal below-the-line entries will include allowances for:

1. Contingencies: an allowance for unforeseen work, such as rework and the correction of mistakes. Internal changes not funded by the customer will use some or all of this allowance.
2. Cost escalation: an allowance that becomes necessary in projects of long duration in times where the rate of national cost inflation is significant. Some contracts will allow re-negotiation of the total project price to compensate the contractor wholly or partly for increases in the costs of labour and materials.
3. Provisional sums: these are cost estimates for work that is not included in the contract price and which might not need to be charged to the customer. They warn the customer of additions to the price that might be needed, but which cannot be firmly defined when the contract is made. For example, if the customer agrees to free-issue materials for the project that have been salvaged from demolition, the contractor might want to have the cushion of a provisional sum to cover the cost of providing new materials if the old materials are found to be unfit for purpose.

The internal departmental and task budgets issued at the beginning of every project must be based on the raw estimated prime cost, with no additions for any of the below-the-line items. Then the process of contract administration begins by amending the issued budgets and project price from time to time as authorised changes occur. The rules should be as follows:

1. The costs of scrap and re-work and any similar task overspends will not affect the issued budgets but must be viewed and managed for what they are: unauthorised overspending (variances).
2. The estimated costs of *authorised* internal changes that will not be funded by the customer should result in additions to the issued budgets as appropriate. The sums thus added must be deleted (drawn down) from the contingencies' allowance.
3. The estimated costs of changes requested by the customer will be added to issued budgets and the associated price increase must be added to the total project price.
4. Increases through cost escalation may be added to budgets provided that the customer has approved a corresponding addition to the project price. These increases can be funded by drawing down the appropriate amounts from the escalation allowance.

That is a simplified summary of a complex process, which can also include such mysteries as changes in currency exchange rates (avoidable to some extent if all suppliers and sub-contractors can be made to quote their prices and rates in the home currency). Contract and budget administration can need considerable clerical effort and it also needs good bookkeeping skills. Cost engineers in the programme support office can oversee this function.

Cost reporting and earned value analysis

Project and programme managers will usually find that they have to devote some of their valuable time in compiling progress and cost reports. Many of these reports will be for internal digestion but, for some projects, detailed cost reports must be prepared for the project owners. Prudent managers will delegate most of this irksome task to the programme support office.

Cost reporting is of little value if it is not done with direct relevance to the associated value added to the project or, put another way, to the progress that has been made. If a report simply states that 50 per cent of the project budget has been spent, one can imagine the resounding 'so what' from senior management. But reporting that 60 per cent of the project has been finished for a cost of only 50 per cent of the total budget will produce a far happier reaction.

So, how can spending be compared with value added? There is a well-known process called earned-value analysis. Much has been written about the method and it is described (for example) by Fleming and Koppelman (2006). The method relies on collecting cost and progress data for every part of the WBS and then rolling up the results for the entire project. The method has its uses (this writer employed it in his junior days) but the results must be viewed with discretion. The most useful products of earned-value analysis are the cost performance index (CPI), and the less frequently used schedule performance index (SPI). Each of these indices should be unity or above to indicate satisfactory performance.

The method allows the project manager to divide the budgeted costs of all the work remaining to be done by the CPI to obtain an estimate of the probable remaining costs.

Earned-value analysis has the disadvantage that, when carried out down to the last detail, it is extremely labour intensive because it demands accurate and frequent reporting of actual costs and estimated progress for every part of the WBS. It can also produce anomalous answers, such as when costs are reported for a job against which no progress has been reported – which will predict a job (and therefore project) cost of infinity. When the data are analysed by hand this is no big problem, because the analyst will use common sense. But when the computer is used (as it must be for large projects) the report can be fit only for the rubbish bin.

However, if cost, budget, and progress data can be entered in a report with the format shown in Figure 14, the principles of earned-value reporting can be obtained for substantially less effort. This method avoids the difficulty of getting into the detail of every small task. As with so many other project management control functions, the detailed work can be placed in the programme support office.

Project cost report summary Page of pages

Project title: Project number: Report date:

A Item	B Cost code	C Original budget	D Authorized budget changes	E Authorized current budget C+D	F Total costs at this report date ACWP	G Value earned at report date BCWP	H Cost index CPI	J Forecast costs remaining (E - G) / H	K Forecast final project cost F + J	L Forecast variance at completion E - K

Abbreviations: ACWP = actual cost of work performed BCWP = budget cost of work performed CPI = cost performance index

Figure 14 A cost report format that incorporates some earned value analysis principles

Implementing management change projects to realise the intended benefits

Internal management change projects bring their own peculiar progress and cost management problems. For the first phases, when the new systems or other changes are being designed, the control of labour, materials and sub-contract costs follow the same principles that apply to any commercial or industrial project. But, unlike those projects, the project manager's role extends well beyond the design, procurement and building stages that would normally end in handover to the customer. Now the organisation is not only the contractor but is also the customer. In fact the real work is only begins when the project enters its crucial implementation phase. And the success of that depends not only on those working in the project team, but on everyone in the organisation who will be expected to learn and use the new procedures, accept different job roles, change their place of work, or even be asked to leave the organisation quietly under a redundancy compensation scheme.

When a management change project moves into its implementation phase, senior management, other stakeholders, and the project manager will be looking not so much at cost control, but at realising the benefits that the project was originally expected to produce when its business plan was formulated. Much has been written in recent years on benefits realisation (see for example Bradley, 2006).

The project design must include measures that will allow the expected benefits to be recognised when they occur. Fowler and Lock (2006) stress that each intended benefit should be set in the business plan as a quantity that will be recognisable in the accounts or as some other *measurable* improvement in other organisation performance factors, together with the date when that benefit will be realised. Financial ratios can be valuable indicators for this purpose, (see for example Friedlob and Schleifer, 2002).

Communicating the project objectives

Senior management can be faced with a dilemma about how to communicate the intentions and objectives of a change project to the organisation's staff at large.

There can be a danger in releasing information about a change project too early, or by allowing snippets of advance information to leak to the staff at large, particularly when senior management and their advisers have no clear idea about the project details or even whether or not the project will actually happen. In a real case, an organisation was considering the removal of its London headquarters to a provincial town. No decision had been reached about the possible new location, the timing of the move, or indeed whether or not the organisation would move at all. Under those conditions it would have been wise to keep the project under wraps until at least some of the decisions had been made. However, the staff soon learned that various senior managers were travelling to different parts of the country, and taking one or two administrative staff with them. Exeter, Swindon, Warwick and Newbury were all visited in turn, and after each visit rumours circulated that the organisation would be moving to Exeter, or Swindon, or Warwick or Newbury, depending on which location had been visited last. All this become very unsettling, and productivity dropped whilst small groups of people could be seen from time to time wearing anxious expressions and wondering about their job security. In the event, Newbury was chosen for the business plan and the site for a new building was even found, but the board vetoed any move because of the high capital cost involved. So all the gloom, alarm and despondency caused among the staff could have been prevented.

A task force organisation will allow the project team to be located away from the main offices, at least until a final business plan has been made. However, there will come a time when communicating either a senior management decision or the organisation's intentions must be communicated honestly and openly to all the staff. Staff will be more cooperative during implementation if they have been informed previously about any intended change. They will be even more cooperative when they have actually been consulted about a change and asked for their views. Sometimes staff representatives can even be invited to serve on the task force.

How and when these communications are set in place will depend on the nature of the project, the kinds of staff jobs involved, and the general organisation culture. Naturally the main body of staff will not be competent to comment on all the aspects of a technically led change, such as the introduction of new IT, but some consultation can prevent expensive mistakes. These difficulties present a big problem to which there is no universal solution. External consultants, who have had experience of similar projects in other organisations, are sometimes well placed to give advice.

Senior management support for programme management

The role of senior management in supporting the individual project manager has always been important but it is a critical factor for the success of corporate programme management. Kerzner (2000) puts this succinctly by describing senior managers as 'the architects of project management cultures'. He cites numerous case studies that emphasise the nature of this role. This can be summed up as giving wholehearted and unflagging support to project managers, whilst resisting the temptation to interfere in their daily tasks.

Senior managers must promote the essential partnership between the procurement and engineering functions, and must always be willing and available to resolve conflicts in any part of the organisation.

Support from senior management includes imposing discipline to ensure standardisation of project management practices and procedures throughout the organisation. That support is crucial also for the efficient functioning of the programme support office, whose role was outlined earlier in this document.

In programme management, it is the senior managers who call the shots in deciding which projects should be authorised and those which should be rejected or returned to their potential sponsors for better definition. For commercial projects this means negotiation with external customers; for internal projects this means improving or clarifying their business plans.

Senior management support must never be confused with senior management interference. Support in developing a project management culture does not mean interfering in the day-today activities and methods of individual managers. Kerzner (2000) cites one case where a steering committee of senior managers was formed with the good intention of providing support to project management generally. It failed in its purpose because different individual members of that steering committee frequently interfered in the day-to-day activities of project managers and gave those managers conflicting guidance and instructions.

Senior management support excludes tinkering unnecessarily with the relative priorities between concurrent projects. Senior managers must have confidence in schedules that have been expertly calculated in multi-project resource scheduling, where the driving priorities are directly and correctly sourced from the individual project target completion dates agreed with the project customers.

However, only senior management can decide and act to pull the plug on a project that is travelling towards inevitable failure. They must also pull that plug in time to prevent the sunk costs spiralling to levels that will impact on other projects in the programme. Hartman (2000) is one writer who emphasises this need to identify doomed projects in time and arrest their fall to financial disaster by wielding the axe.

Concluding summary

This paper, after giving a few essential definitions, has outlined some of the main characteristics of project and programme management. Now, to conclude, here is a recapitulation of the main points (with one or two additional hints and tips inserted here and there).

- The life cycles, cash-flows, and profit expectations are fundamentally different for projects conducted for external customers and internal management change projects. A programme usually contains a mix of both these kinds of projects.
- The contractors of commercial and industrial projects expect profit when each project is handed over but management change projects are usually conducted for longer term and longer lasting benefit realisation.
- Every project, of whatever type, should be defined as fully and accurately as possible before it is authorised. Plans should use the critical path method, and detailed task lists should be arranged in hierarchical work breakdown format.
- All elements of the work breakdown should be coded, to facilitate subsequent processing, filtering and sorting by the computer database.
- Here are some additional hints and tips for the designers of coding systems.
    - The best coding systems are standardised, so that they work across all projects in a programme and can be used in every department in the organisation.
    - Codes should agree with or relate to the organisation's code of accounts.
    - There is always a temptation to expect too much of a code. The temptation to add fields for things that would be 'nice to have' must be resisted. Always remember the people who will be expected to use these codes. One 'brilliant' system of job coding for a mining project failed disastrously because none of the people working in the exposed and dangerous conditions at the mine could be persuaded to moderate their language and write 18-character codes on their timesheets and other work documents.
    - Always remember and obey the acronym KISS, Keep It Simple Silly.
- Project engineers and other technical staff need to be cost conscious, but project and programme managers also need to be cash conscious.
- All who work in organisations and projects, and all who write about their activities need to appreciate the vital (but often neglected) role played by the procurement and supply chain functions.
- Senior management must achieve programme portfolios in which the funding needed for management change projects does not outstrip revenues from normal operations and commercial projects. Only those change projects with sound business plans, should be authorised and care must be taken not to authorise two or more concurrent change projects where those projects would not be mutually compatible.
- Organisational requirements for external and internal projects can be different. As a very brief generalisation:
    - An organisation that regularly conducts a number of concurrent small projects might best be organised as a matrix
    - A single large project, or an organisation that conducts a few such projects are cases where each preferred project organisation would be a dedicated pure project team
    - A project task force organisation is best suited to driving a particularly urgent project and every management change project through to success.
- A project or programme support office (PSO) can provide a vital information hub and be the logical home for cost estimating, planning and scheduling, progressing, cost reporting, change administration, contract administration, and all those other functions that are necessary but which might otherwise absorb too much project managers' time. Further the PSO can, given senior management support, safeguard the implementation and practice of cross-project standard procedures that is so important in programme management.

- The procurement and supply chain organisation can include home-based and overseas purchasing agents and an external freight forwarding organisation. All these functions have to be coordinated within each project and across the programme to achieve economies of scale in purchasing and freight costs, and to ensure that projects get their vital supplies of equipment and materials on time, within budget, and fit for purpose.
- Partnerships in purchasing are not only to be encouraged externally between buyers and suppliers, but also internally between the engineering and purchasing functions. Purchasing managers, rather than complaining about lack of cooperation from the engineers, must market their departments' contribution to project success internally. Senior management must encourage that drive for internal partnership.
- When an organisation employs all or a significant proportion of its project or programme labour, resource scheduling across the entire programme becomes essential to minimise both overloads and idle time. Those responsible for resource scheduling should be equipped with competent software, chosen and purchased with the same degree of care as any other high-cost purchase operation.
- Those who carry out planning and resource scheduling should be picked for their aptitude for problem solving. They must always resist demands from others that will complicate the scheduling process unnecessarily, whilst on the other hand must always be seeking ways to simplify and accelerate the planning and scheduling process.
- All resource schedule calculations should be driven by real project needs, factored by the delivery dates contracted with the project customers. Senior managers must be discouraged from any temptation to interfere artificially with these real priorities. This is an exceptional case where the computer actually makes management decisions, rather than the more usual case where the computer merely processes and presents data for management consideration.
- Progress control should be exercised through management by exception principles.
- Change requests for every kind of project must be subjected to critical examination before authorisation. Procedures must be in place for this process, and they can be administered from the programme support office. Changes funded by customers are usually acceptable (sometimes even desirable for the additional profits that they can bring). Changes funded internally, which means all changes to internal management change projects, must be examined with particular rigour; changes that are merely desirable rather than essential should normally be disallowed.
- Historical cost reporting and cost control have to be recognised as related by essentially different functions. The fundamental ingredient for controlling labour and overhead costs is efficient working and good progress control. The costs of purchased goods and services (which can be as high as 80 per cent of total project costs) are best controlled through established competitive purchasing procedures, with every item defined as well as possible in advance. Remember that once an order has been placed that exceeds budget, the cost damage has been done.
- Earned value measurement in its full form can be labour intensive but can yield misleading results. However, intelligent cost reporting can be made with less effort, yet still provide a good degree of earned value reporting (a preferred cost report format was shown in Figure 14).
- The success of all projects depends on the people in their organisations. This is particularly true for management change projects, where realising the intended benefits usually depends on many organisation staff who work in departments not normally connected directly with projects.

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