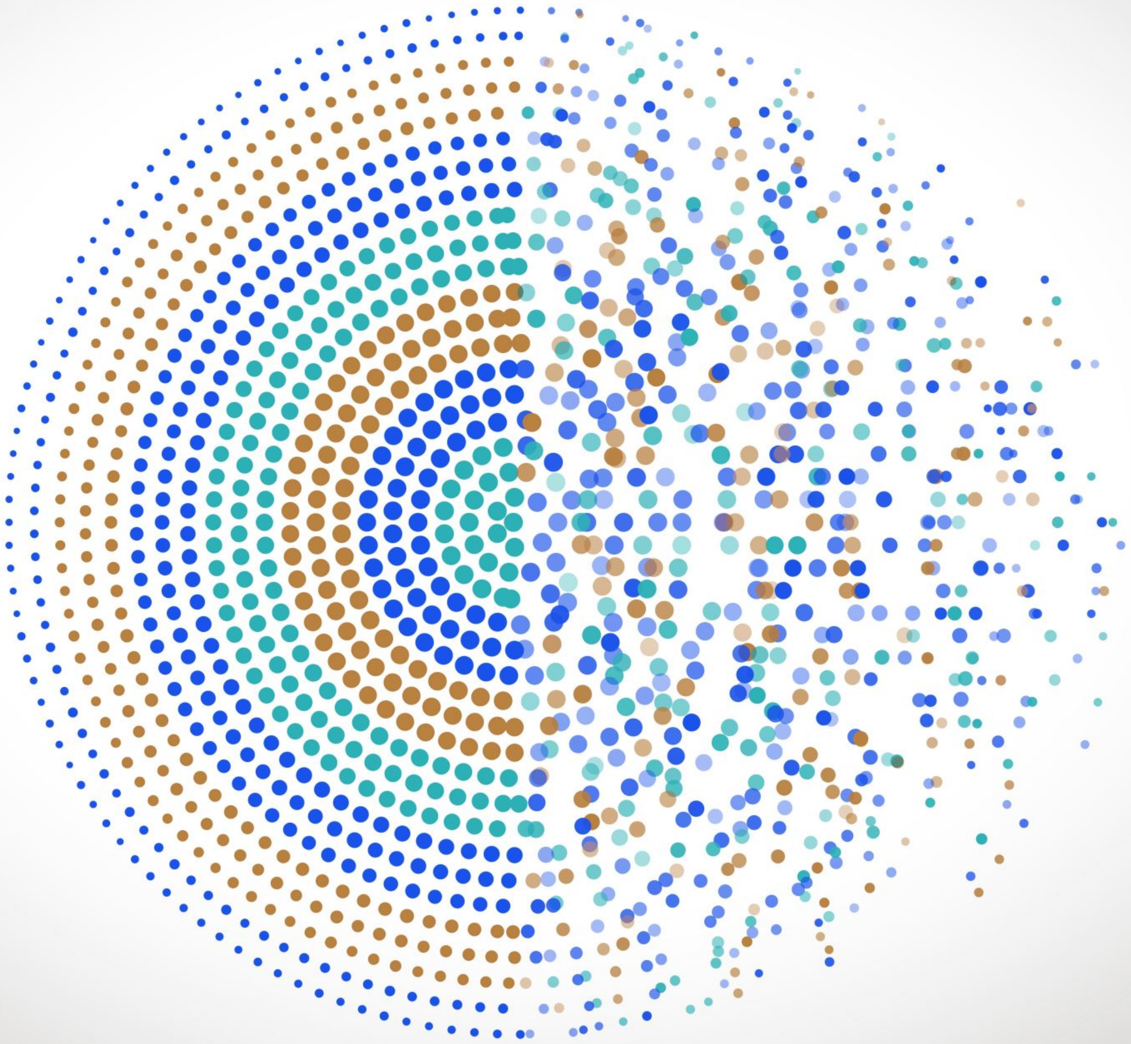


PROJECT MANAGEMENT

- **Project Management and Engineering Economics**
- **Dr. Denizhan DEMİRKOL (Ph.D.)**
- **WEEK 13**
- **Rethinking time planning: the critical chain approach**
- **Stakeholders and Quality**
- **Risk and Oppurtunity Management**

- Previous lecture presented some detailed planning techniques for time – in particular the basics of **the critical path method (CPM).** Having spent some time getting to grips with these techniques, **you now encounter a lecture that states that these techniques do not work**
- The obvious question arises as to why these were covered at all in the first place. There are two reasons:

● in order to understand the shortcomings of the techniques and search for potential solutions, **you must first understand the techniques themselves;**

● *many organisations still require the use of the original techniques and have not yet adopted the solutions that are presented.*

Problems associated with the CPM approach to planning and controlling

1. All goals are based on estimates, which contain uncertainties. We are poor at meeting these goals because the underlying methods of planning contain basic flaws. These include the myth of the Gaussian distribution in planning – that activities will have a most likely time and the actual time taken could be either side of this. The reality is that activities will sometimes run to time, often late, but almost never early (see Parkinson's Law later in this section).
2. Estimates of activity times generally include a large safety margin – people will estimate according to their worst past experience of that type of activity but, as will be shown below, this safety margin at each activity does not help in achieving on-time completion.
3. Network diagrams (A-o-N) usually contain a latest start time for activities. For non-critical activities, this builds in slack at the start of activities. Perversely, this creates the situation where these activities, if started at their latest start times (as cash flow pressures often wrongly dictate), also become critical. The more critical paths in a project, the greater the chance of failing to meet time goals, and the less chance of 'focus' that the project manager will have.
4. Because of this method of scheduling activities, the situation arises where '. . . a delay in one step is passed on in full to the next step. An advance in one step is usually wasted.'[6] Worse still, where there are parallel activities, regardless of an early finish in one of the paths, the biggest delay is passed on to the subsequent activities.
5. The way that we measure progress is in error – generally by the time a project manager is notified of a problem it is already too late to prevent it having an impact. This is represented in another piece of project folklore – that a project will spend 90 per cent of its time 90 per cent complete. It is possible to ignore problems when measures indicate that progress is satisfactory, particularly those that rely on managers' estimates of per cent complete.
6. Related to 3 and 4 above, **student syndrome** is identified as where, despite people being given extra time (slack) for an activity, the extra time is wasted at the front end, and they often won't start the activity until the latest possible time.
7. It is usual in business projects for people to have to multi-task. The effect of this is to increase the lead-time for all the projects – see below.

- 1- Tüm hedefler, belirsizlikler içeren tahminlere dayalıdır. Bu hedeflere ulaşmada yetersiz kalabilmekteyiz çünkü planlamanın altında yatan yöntemler temel kusurlar içermektedir. Bunlar, planlamadaki Gauss dağılımı mitini içerir - faaliyetlerin büyük olasılıkla bir zamanı olacaktır ve harcanan gerçek zaman bunun her iki tarafında olabilir. Gerçek şu ki, faaliyetler bazen zamanında, genellikle geç gerçekleşir, ancak neredeyse hiçbir zaman erken olmaz (Parkinson Yasası).
- 2- Faaliyet sürelerine ilişkin tahminler genellikle büyük bir güvenlik marjı içerir - insanlar bu tür faaliyetlerle ilgili geçmişteki en kötü deneyimlerine göre tahmin yapacaklardır,ancak, her faaliyetteki bu güvenlik marjı, zamanında tamamlamaya yardımcı olmaz.
- 3- Ağ diyagramları (A-o-N) genellikle etkinlikler için en son başlangıç zamanını içerir. Kritik olmayan faaliyetler için bu, faaliyetlerin başlangıcında gevşeklik oluşturur. Ters bir şekilde, bu durum, bu faaliyetlerin, en son başlama zamanlarında başlatılırsa (nakit akışı baskılarının genellikle yanlış bir şekilde dikte etmesi nedeniyle), aynı zamanda kritik hale geldiği bir durum yaratır. Bir projedeki kritik yollar ne kadar çoksa, zaman hedeflerine ulaşamama şansı o kadar artar ve proje yöneticisinin sahip olacağı 'odaklanma' şansı o kadar az olur.
- 4- Daha da kötüsü, paralel faaliyetlerin olduğu yerlerde, yollardan birinde erken bir bitişe bakılmaksızın, en büyük gecikme sonraki faaliyetlere aktarılır.
- 5 İlerlemeyi ölçme şeklimiz genellikle hatalı olabilir – sıklıkla bir proje yöneticisine bir sorun bildirildiğinde, sorunun bir etki yaratmasını önlemek için çok geç kalınmış olur.
- 6- Yukarıdaki 3 ve 4 ile ilgili olarak, öğrenci sendromu, insanlara bir aktivite için fazladan zaman (boşluk) verilmesine rağmen, fazladan zamanın **ön uçta** boşa harcanması ve genellikle aktiviteye başlayana kadar fazladan zaman olduğundan dolayı başlamaması ve en geç zamanda başlaması olarak tanımlanır.
- 7 İş projelerinde insanların birden fazla görev yapması olağandır. Bunun etkisi, tüm projeler için hazırlık süresini artırmaktır - aşağıya bakın.

Multi-tasking

- **The immediate effect is to make projects take considerably longer than they need to.**
- In the case of one new product development team, one can only imagine the effects of having an average of 12 projects per person ongoing at any one time.
- **The reality is, therefore, worse than in the simple example given above as the simple model includes the assumption that people can put down and pick up a project without any loss of time.**

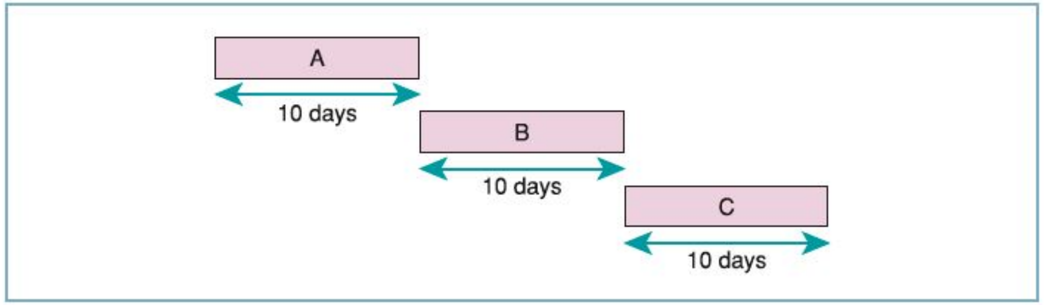


Figure 7.1 Activities completed in strict sequence

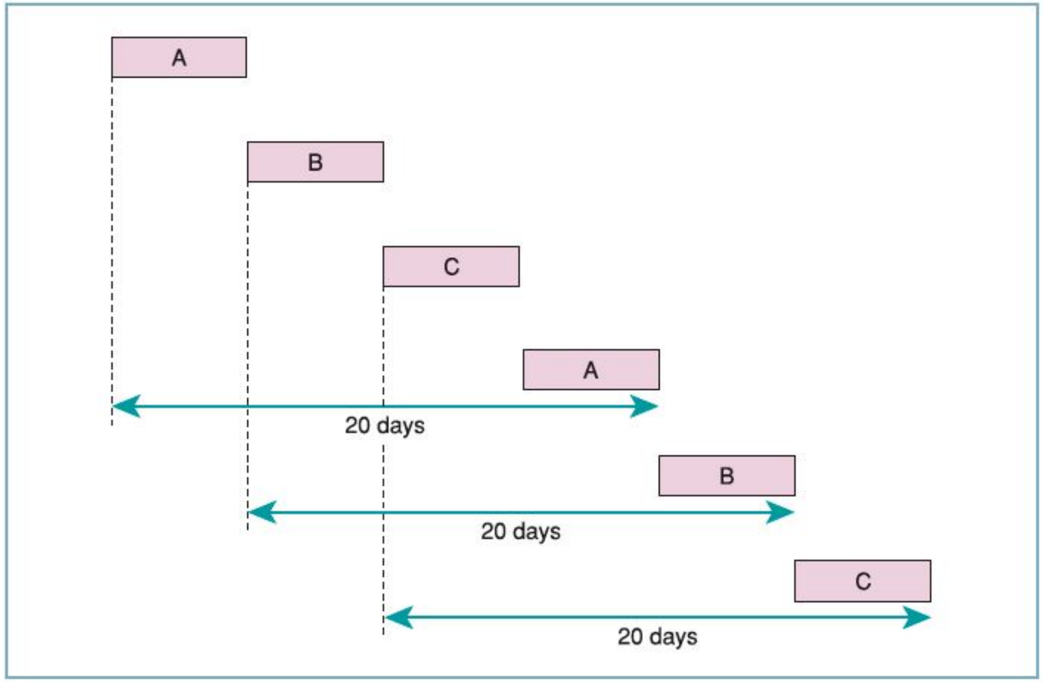


Figure 7.2 The effects of multi-tasking

Multi-Tasking

- ***Where bad multi-tasking was evident in a software company, programmers would regularly lose 1–2 days of work when transferring between tasks.***
- This was caused by the need for refamiliarising themselves with the logic of the task that they were undertaking. These days were lost because of the inefficiency of the system in which they were working. The management system should have identified this and worked to prevent such a waste of time.

Problems with estimates

Typical problems with estimates include:

- inappropriate use of estimates – people being asked for rough estimates as to how long a particular activity will take, only to find that this becomes the target time enshrined in a committed plan;
- inappropriate data used to build estimates – people either taking unrepresentative previous experience or not checking whether this was in fact a good representation of the reality of carrying out the task (it is not unusual for such situations to exist for many years where there is a lack of review);
- the estimates are used out of context – having given an estimate of time required to do some work, this is then used despite significant changes having been made to where and how the work is to be carried out.

As commented in the previous chapter, estimates are a guess as to how long an activity or sub-project will take. They should not then be imbued with more certainty than they deserve!

- If we now look at what happens to that estimate when the time comes to do the work, we see that there are a number of things that happen.
- **The first is that now we have 5 days to do the job – it will almost certainly take 5 days, and usually more. Does this make us bad estimators? Well, there are certain other factors that intervene:**

- **Parkinson's Law** – an activity will expand to fill the time available.[8]
- Human nature for many of us is also to leave the project until the last possible minute (called student syndrome for some reason!) – meaning that the 2 days of real work doesn't need to be started until day 4. We start on day 4 and what happens . . .?
- The unexpected computer crash (that we had allowed time for initially) happens. The problem is that now the time that would have allowed us to recover this has been used. The activity is almost certain to be late. The safety was used at the start of the activity and did not provide the necessary 'buffer' between the task and the completion date.

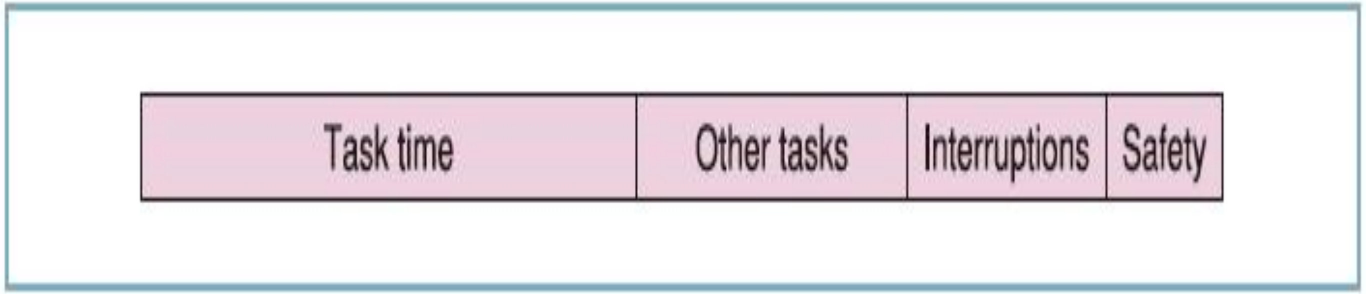


Figure 7.3 Building a time estimate

Activity completion profile

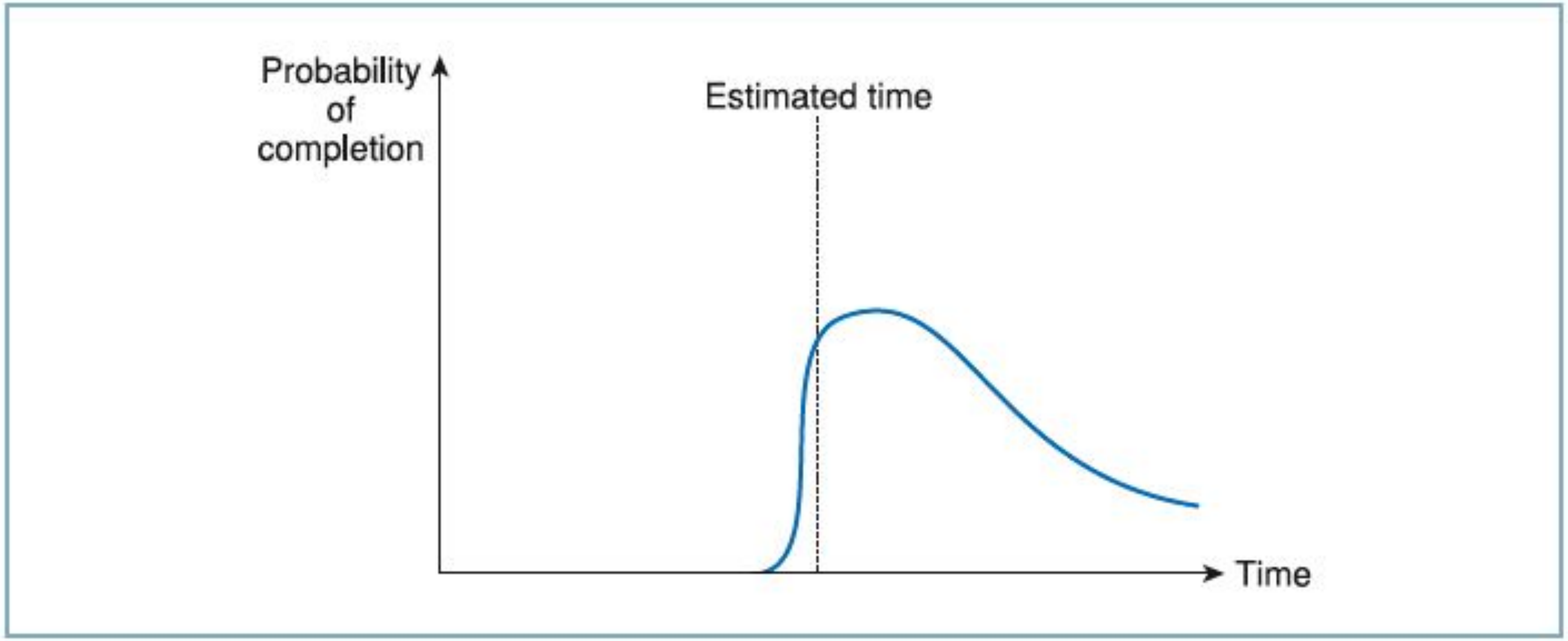


Figure 7.4 Activity completion profile

The result of this is that time has been wasted on the project – the task still took only 2.5 days (2 days for the activity and half a day for the computer crash), but the activity time seen is 5.5 days. This is typical and results in an activity profile for completion of projects, as shown in Figure.

- Figure shows the chances of early completion of an activity to be very low – we know this from practice. In the unlikely event that someone does finish some work early, they are unlikely to announce the fact for a number of reasons:

● they have the opportunity to ‘polish the product’;

● they do not want to give the boss an excuse to give them more work to do;

● they provided the estimate and do not want to be seen to have overestimated the task time;

● they know that this shorter time will become the ‘expected time’ for the activity and do not want to have their own margin of safety reduced

Managing by constraints in projects
The theory of constraints (TOC)

- The theory of constraints (TOC) was the result of the application of a structured logic approach to the problems of a manufacturing environment.

1- Identify the constraint – the critical path and the critical resources.

2- Exploit the system constraint (Having identified these, exploiting means that anything that prevents that part of the system performing to its maximum potential is to be removed).

3- Subordinate everything else to the constraint (make the constraint the point around which schedules are based and ignore local efficiencies that do not consider the system as a whole).

4- Elevate the constraint (Elevating the constraint means increasing the flow through that part of the system -removing it as a constraint).

5- Go back and find new constraints, repeating the process.

Estimating Principles

- Estimates (both initial and to-finish) should be based on the activity times only, with no **safety** added. This relies on a number of underlying changes (see later discussion) including buy-in from all people estimating and a commitment to acceptance that 50 per cent of activities will finish early and 50 per cent late. Finishing late is therefore to be expected for half of all activities, necessitating removal of the stigma of a late finish.
- Safety should be included at the end of a critical path – not before. Where there are feeder paths (parallel activities that lead on to the critical path), the safety buffer should be placed at the point where the feeder joins the critical path (see Figure 7.7).
- Time plans establish precedence relationships but should be treated as overviews only. The nature of project management needs to reflect the dynamic of the actual situation, and accommodate changes as they occur. Furthermore, given the **uncertainty** of plans, it is vital that all the parties involved are given regular updates on when their input is required. This statement, albeit trite, reflects the need for greater communication to ensure that critical activities can proceed without incurring any delay.
- Progress should be monitored by the critical path – rather than per cent complete, a time to finish is now required from sub-project managers. This can be represented by the state of the project buffer (the slack time at the end of the project).

Buffering the feeder paths

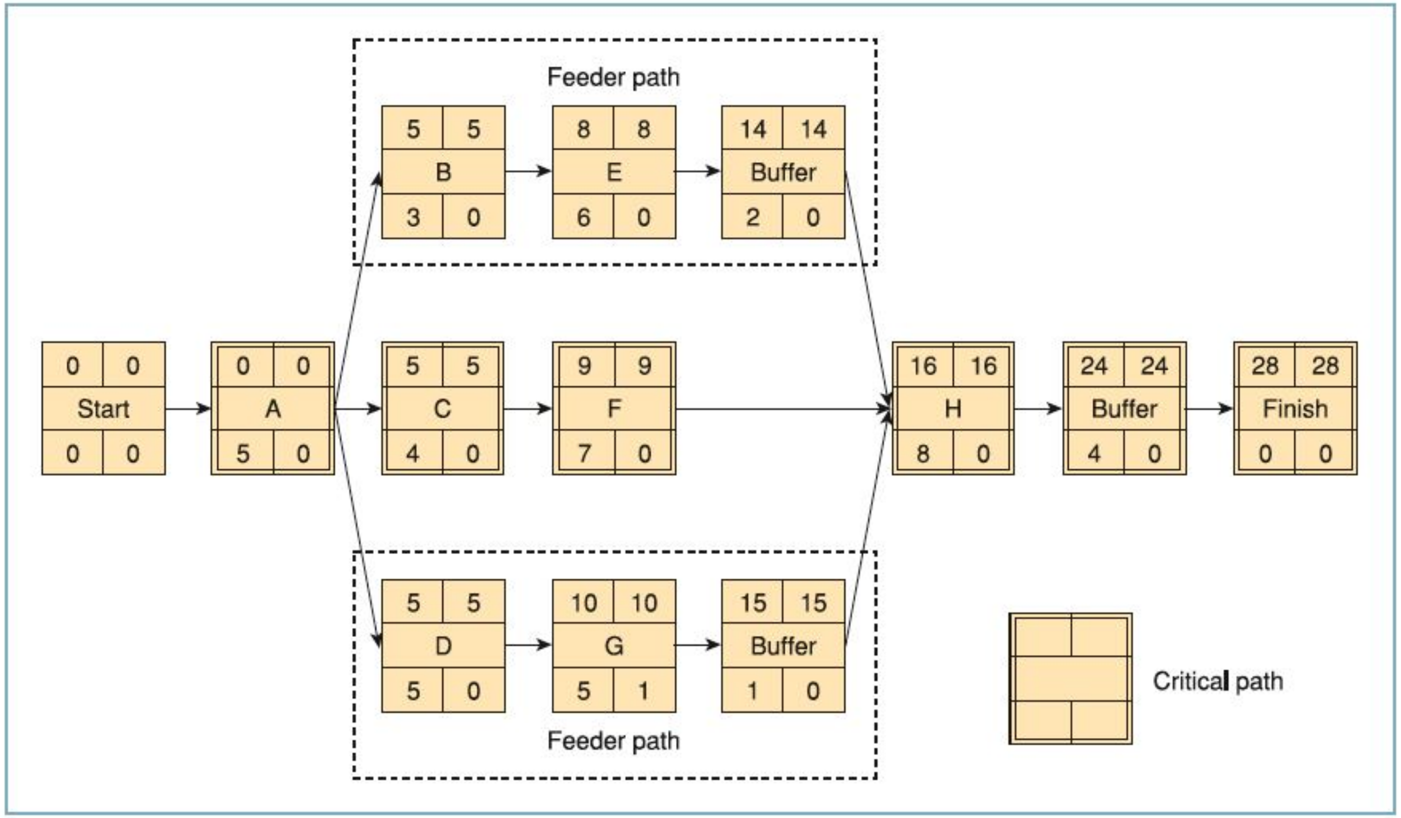
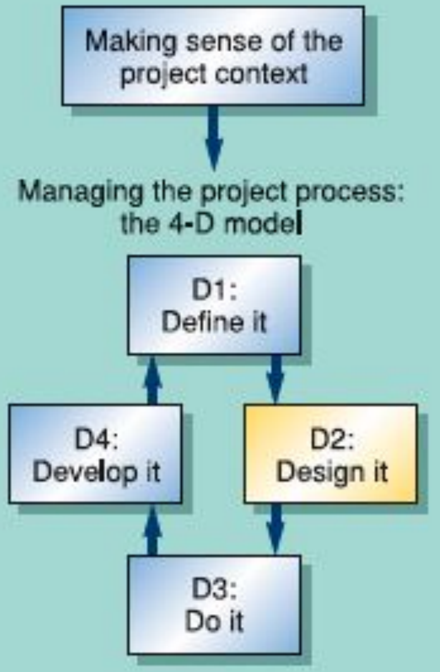


Figure 7.7 Buffering the feeder paths

Benefits of critical chain scheduling

- Critical chain project plans with buffers as described and due-date constraints removed from activities wherever possible are far more stable. This stability is a **major benefit of critical chain scheduling.**
- Moreover, when a non-critical activity becomes critical it is only necessary to reconsider the criticality as far as the point that the paths merge.
- Non-critical activities often become critical due to resource contentions. These resources (a person, a department, an external organisation or a piece of technology) are now the constraint, and should be protected by a buffer (some time-slack in front of them)
- This added complication to the critical path represents the formation of compound series of activities – often involving different paths – which has been termed ***the critical chain.*** The TOC-the theory of constraints- approach does result in a new approach to performance, particularly at a local (activity) level. This alone has considerable potential benefit.

Cost and benefit planning



'The method I use to estimate costs, is think of a number and double it.' (Project Planner)

'The only people who give reliable estimates are depressed, or worse.' (Professor of Accounting)

Principles

1 In order to provide an assessment of plans it is vital to understand the costs associated with activities and projects and to have a realistic cost plan.

2 Costs should be justified in terms of payback or return on investment as part of a business case.

3 Determining the magnitude of the costs and benefits of projects needs to be carried out critically.

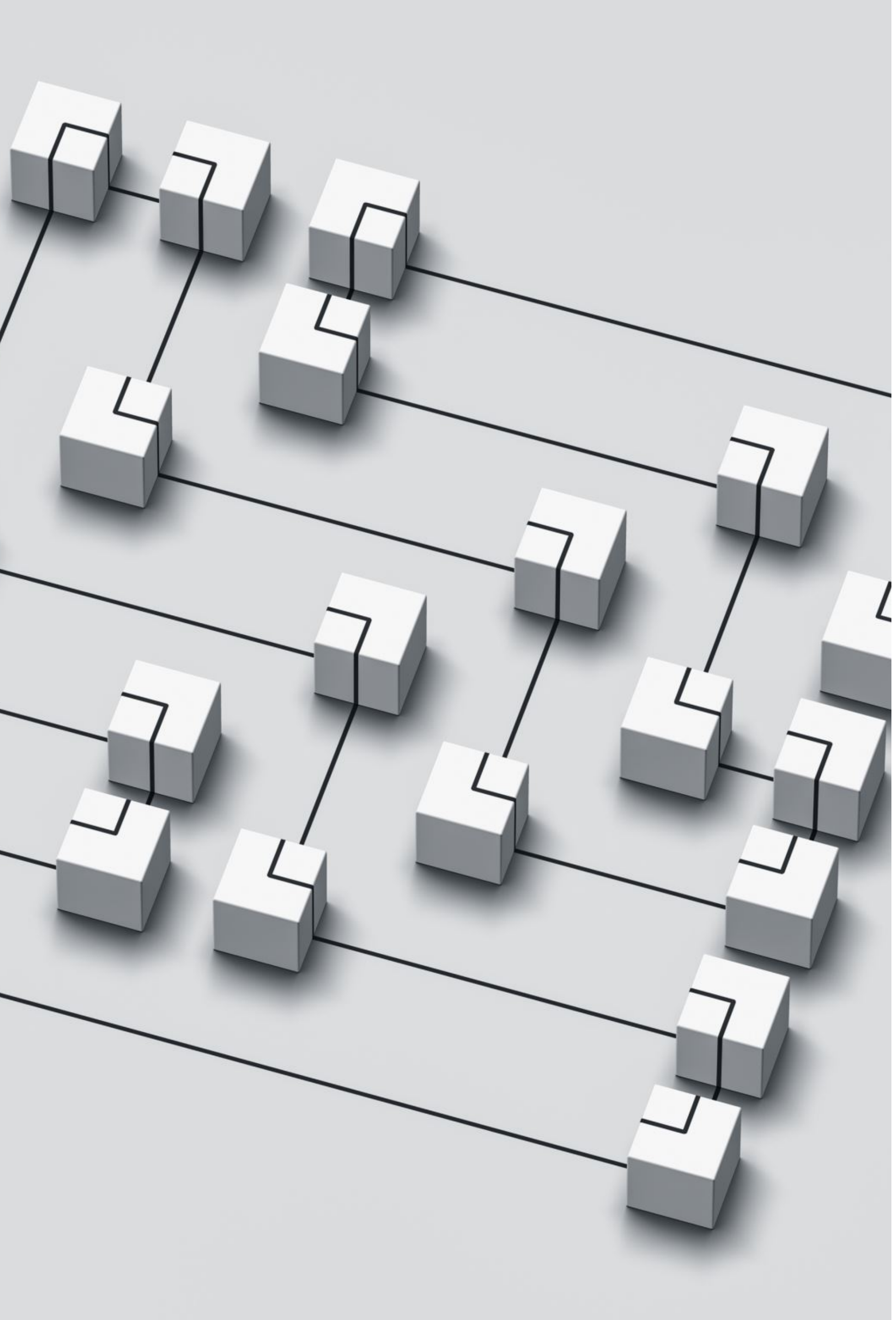
Basics of a cost planning process

The basic relationship between price, cost and profit can be expressed in a number of ways:

$$\left.\begin{aligned} \text{price} &= \text{cost} + \text{profit} \\ \text{cost} &= \text{price} - \text{profit} \\ \text{profit} &= \text{price} - \text{cost} \end{aligned}\right\} \text{ same equation different meaning}$$

Which one applies depends on whether price, cost or profit is fixed first. These differences can be explained as follows:

- in the first case the price is fixed through legislation, for example, or in the case of a **target costing** system (see below), through market analysis;
- in the second the cost is fixed, generally through contract purchase which guarantees that goods will be supplied to you at a particular price. This fixes your costs while your selling price and profits can be varied;
- some agreements state the profit that a company is allowed to make through the system known as **cost-plus** or **reimbursable pricing**.



Approaches to costing

- There are two basic approaches to the preparation of costing information:
- ground-up costing – the estimates of each level in the work breakdown structure are compiled and added together by each level of supervision in the project hierarchy, as would be the case for reimbursable contracts; temelden maliyetlendirme – iş kırılım yapısındaki her bir düzeyin tahminleri, geri ödenebilir sözleşmelerde olduğu gibi, proje hiyerarşisindeki her denetim düzeyi tarafından derlenir ve birleştirilir;
- top-down costing – you are allocated a certain amount of money to complete the project activities and this has to be split between the sub-projects. The allocation is based on either senior management’s estimates or the use of target costing. yukarıdan aşağıya maliyetlendirme – proje faaliyetlerini tamamlamanız için size belirli bir miktar para tahsis edilir ve bu, alt projeler arasında paylaştırılmalıdır. Tahsis, üst yönetimin tahminlerine veya hedef maliyetlendirmenin kullanımına dayalıdır.

Elements of costing

The major elements of cost are:

- **time** – the direct input of labour into activities;
- **materials** – consumables and other items used in the process;
- **capital equipment** – the purchase of the means of providing the conversion process, or part of its cost, maintenance, running and depreciation offset against activities;
- **indirect expenses** – e.g. transportation, training;
- **overheads** – provision of an office, financial and legal support, managers and other non-direct staff;
- **contingency** margin/allowance.

Estimating techniques

Estimating techniques

In the material covered so far, the approach has been to build up the costs from the elements of the WBS and to add to them the elements identified above. In addition to this ground-up approach, there are various techniques that are used. These include:

- **parametric estimating**;
- as . . . but . . . s;
- forecasts;
- **synthetic estimation**;
- using **learning curve** effects;
- **wishful thinking**.

Stakeholders and Quality

Principles

1. Achieving a certain level of quality is one of the primary objectives of most projects, and there are costs associated with this.
2. Quality is a subjective property and is judged by each of the project stakeholders. The outcome has an important impact on customer retention and future trust in projects.
3. Some elements of quality will require conformance, others provide the opportunity for real performance to be demonstrated, while others provide the opportunity for business improvement.

The concept of quality and quality management

REAL WORLD What is quality? Does it matter?

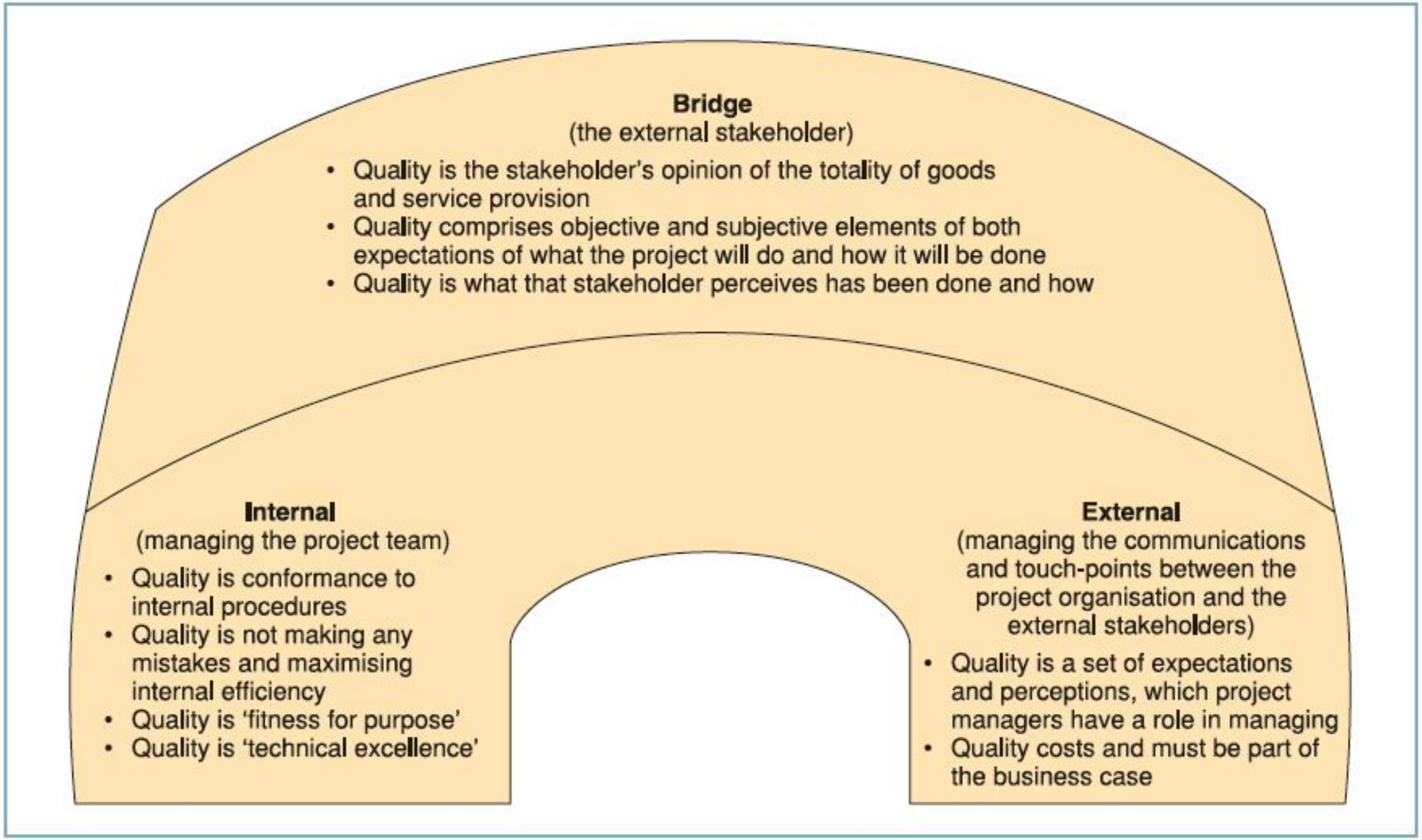
QinetiQ is one of the UK's larger defence contractors (turnover >£1bn to financial year end 2006) and has recently made the transition from government-owned Defence Evaluation and Research Agency (DERA) to being a public company that has to compete for government, and also commercial, work.

Source: Courtesy of QinetiQ

As part of this change, there is now a much greater concentration on the business case for the projects that are undertaken than there was in the past. As a result the concept of **quality** within the firm has come under considerable scrutiny. As a government agency, the costs of projects were less important than the achievement of technically excellent solutions. Quality for the agency was therefore concerned with what is now termed *'gold-plating'* where technical excellence would be maintained, sometimes regardless of the needs of the end-user and traded off against other objectives[2] in a project.

Today, the project managers are required to be far more circumspect about the quality required in their projects – it is clear that quality costs, and that what are termed *'good-enough'* technical solutions may often be superior for both the project and the end-user to the gold-plated version.

Bridge model of project quality management



Quality and stakeholder satisfaction

- Some general principles of stakeholder management come from an appreciation of basic customer behaviour. One part of this concerns the nature of satisfaction. Here, Maister's first law of service is useful, namely that:
- ***satisfaction = perception – expectation***
- That is, the satisfaction is determined by the difference between how the project is perceived or viewed by a stakeholder and how they expected it to perform.

Perspectives on quality management

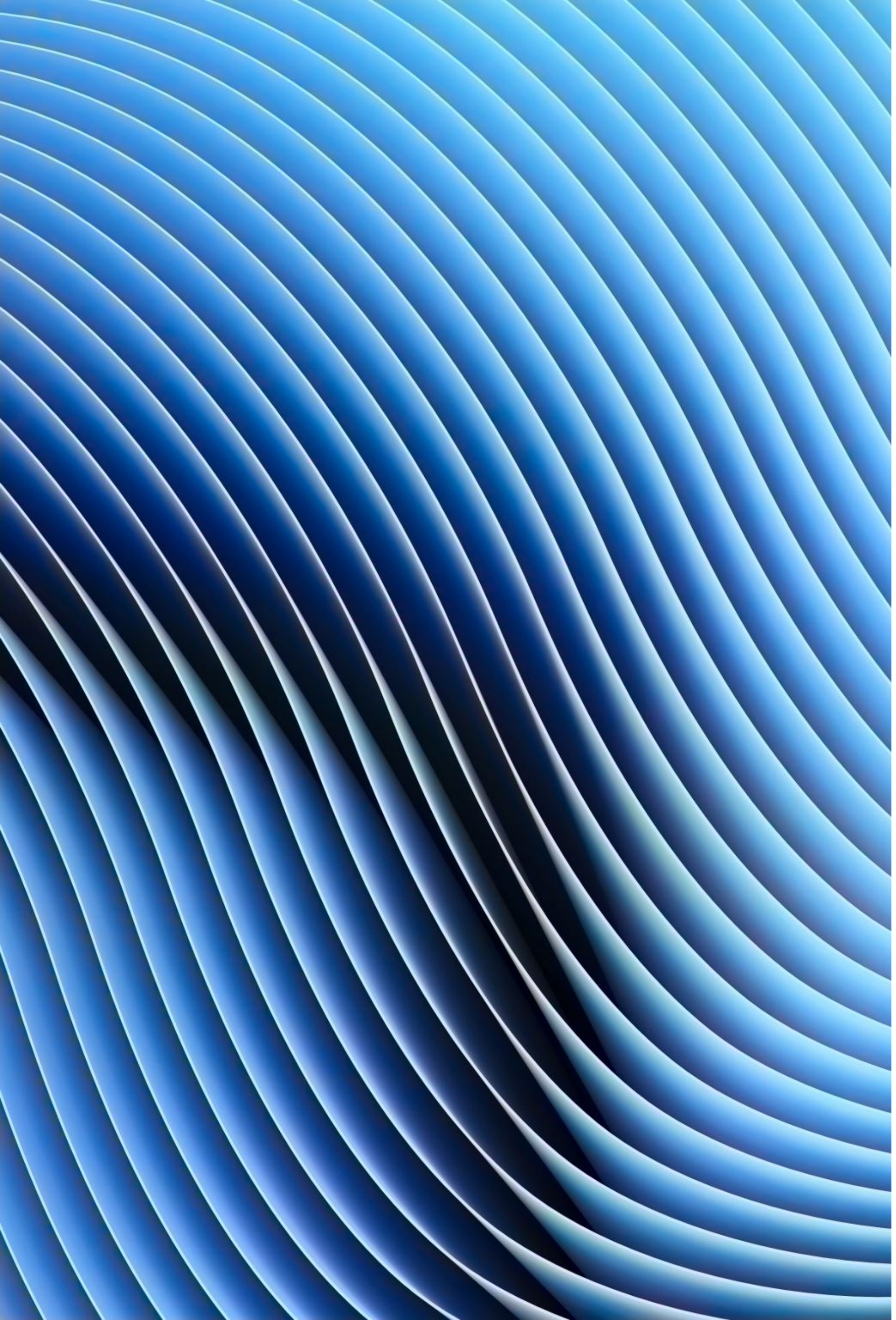
- There is a view that quality is the result of expectations and perceptions that can be managed through two-way communications.

Perspective	*Definition supported*	*Description of approach*
Mathematical	Conformance to specification	The management of quality is limited to the assurance of the 'goodness' of a mechanical product or process. Activities are based on statistical tools, such as Statistical Process Control.[3]
System-structural	Conformance to procedure	This is encapsulated in the approach of the bureaucratic quality system as used as the basis for the ISO 9000 model of quality management. The achievement of a level of quality relies on the development and following of a hierarchical set of procedural documents.
Control-organizational	Continuously meeting customer requirements	In this approach, employees and customers are viewed as key determinants of project quality. This is particularly useful where there are high levels of contact with particular external stakeholder groups during the project.
Economic	Cost of (un)quality	The financial costs and benefits of quality management are assessed against the costs of failure.
Holistic	Continuously meeting customer requirements at lowest cost	The Total Quality approach[4] – relies on a change in the entire way the operation approaches its project processes, from senior management to the front-of-house staff.
Strategic	Quality as competitive advantage	The additional responsiveness that can come from successfully pursuing product and process improvement is treated as part of the competitive strategy of the firm.

Communications planning

- A common technique for communications management centres on the use of a table to identify the nature of the communication (what will be told to whom and in what format), the timing and who is responsible for doing it. We are not considering Daily communication or simple information-sharing activities, which while vital, are not the type of 'grand communications' being considered here – typically key reports, announcements of achievements, technical updates, etc.
- To help structure this the basic stakeholder analysis carried out as part of the Project Strategy formulation process is expanded in Table

Stakeholder	*Communication*	*Timing*	*Format*	*Distribution*	*Person responsible*
Project sponsor	Monthly	Week 1 each month	Short report	E-mail	Project manager
Accounts department	Monthly spend schedule	2 weeks before start of month	Short budget	E-mail	Administrator
Client department	Monthly	Week 1 each month	1-page report	E-mail and noticeboard	Liaison officer



Risk and Oppurtunity Management

'. . . as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know.'

(Donald Rumsfeld)

US Defense Secretary

- The third category is the ‘unknown unknowns’ – those things that come from out of the blue and we could not have known about. For instance, a project to move a factory was thrown into chaos by the take-over of the company. The restrictions placed on the project by the new owners prevented the occupation of the new site and the eventual abandoning of the project. This could not have been known in advance.

Risk and Oppurtunity Management Principles

Principles

1) Risk and uncertainty are fundamentals of projects.

2) There are well-developed approaches that can be applied to the management of risk.

3) While there is always downside potential for a project, there is always upside too. Opportunities are just as important as risk.

On the morning of 1 February 2003, NASA's space shuttle Columbia was returning to earth from a routine mission. Damage to the heat-resistant panels on the left wing of the shuttle sustained shortly after take-off allowed superheated air to reach the aluminium structure of the shuttle, melting it and causing the disintegration of the craft during re-entry into the earth's atmosphere. All seven crew died.

Source: Dennis Hallinan/Alamy

The official investigation report recognised that space flight is still inherently risky, but was clear that the risk here was the result of some particular organisational issues. Specifically, the report states: *The organizational causes of this accident are rooted in the Space Shuttle Program's history and culture, including the original compromises that were required to gain approval for the Shuttle, subsequent years of resource constraints, fluctuating priorities, schedule pressures, mischaracterization of the Shuttle as operational rather than developmental, and lack of an agreed national vision for human space flight. Cultural traits and organizational practices detrimental to safety were allowed to develop, including: reliance on past success as a substitute for sound engineering practices (such as testing to understand why systems were not performing in accordance with requirements); organizational barriers that prevented effective communication of critical safety information and stifled professional differences of opinion; lack of integrated management across program elements; and the evolution of an informal chain of command and decision-making processes that operated outside the organization's rules.*[1]

What is risk?

- Two classic definitions of risk are:
- The possibility of suffering harm or loss (PMI, 2004)
- Uncertainty inherent in plans and the possibility of something happening (i.e. A contingency, «arıza») that can affect the prospects of achieving business or project goals (BS 6079)

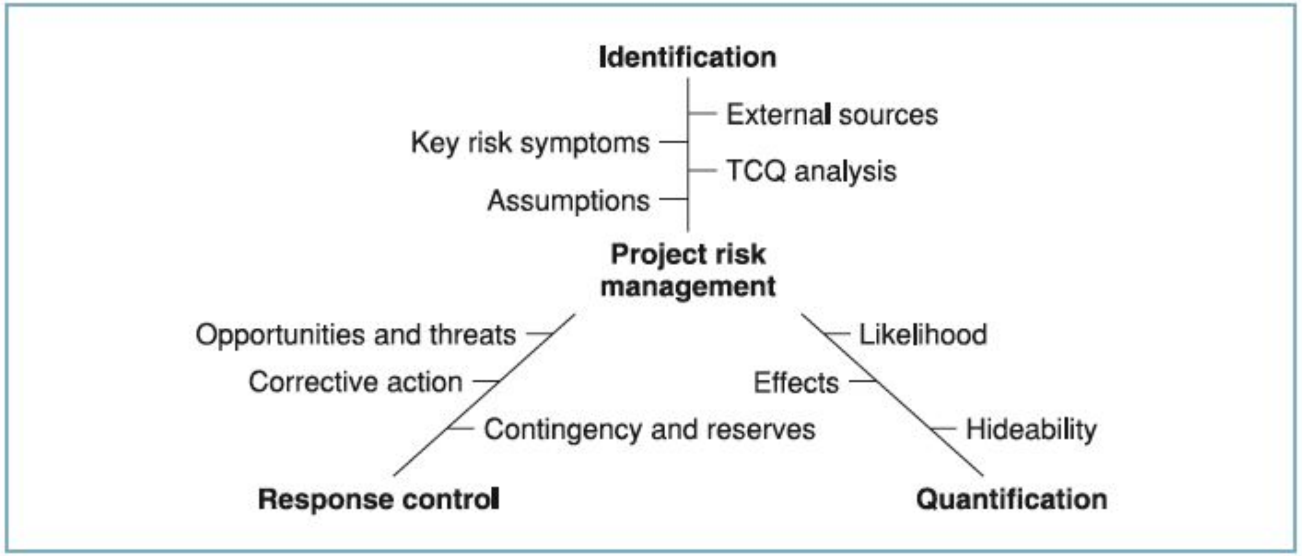
The second definition considers the fundamental of any looking into the future – as happens in project planning – that there is uncertainty. The objective here is not to eliminate uncertainty or risk. Indeed, an accepted notion in many aspects of business life is that risk is proportional to return.

The greater the risk that you run, the larger the return could be (if all goes well, etc.).

However, this does apply in some respects to projects and their management.

Framework for risk management

- We shall divide the activity of risk management into three main areas ***– identification, quantification and response control or mitigation.***
- There are many accompanying tools and techniques for each part of this, and some attributes of each are shown in Figure.



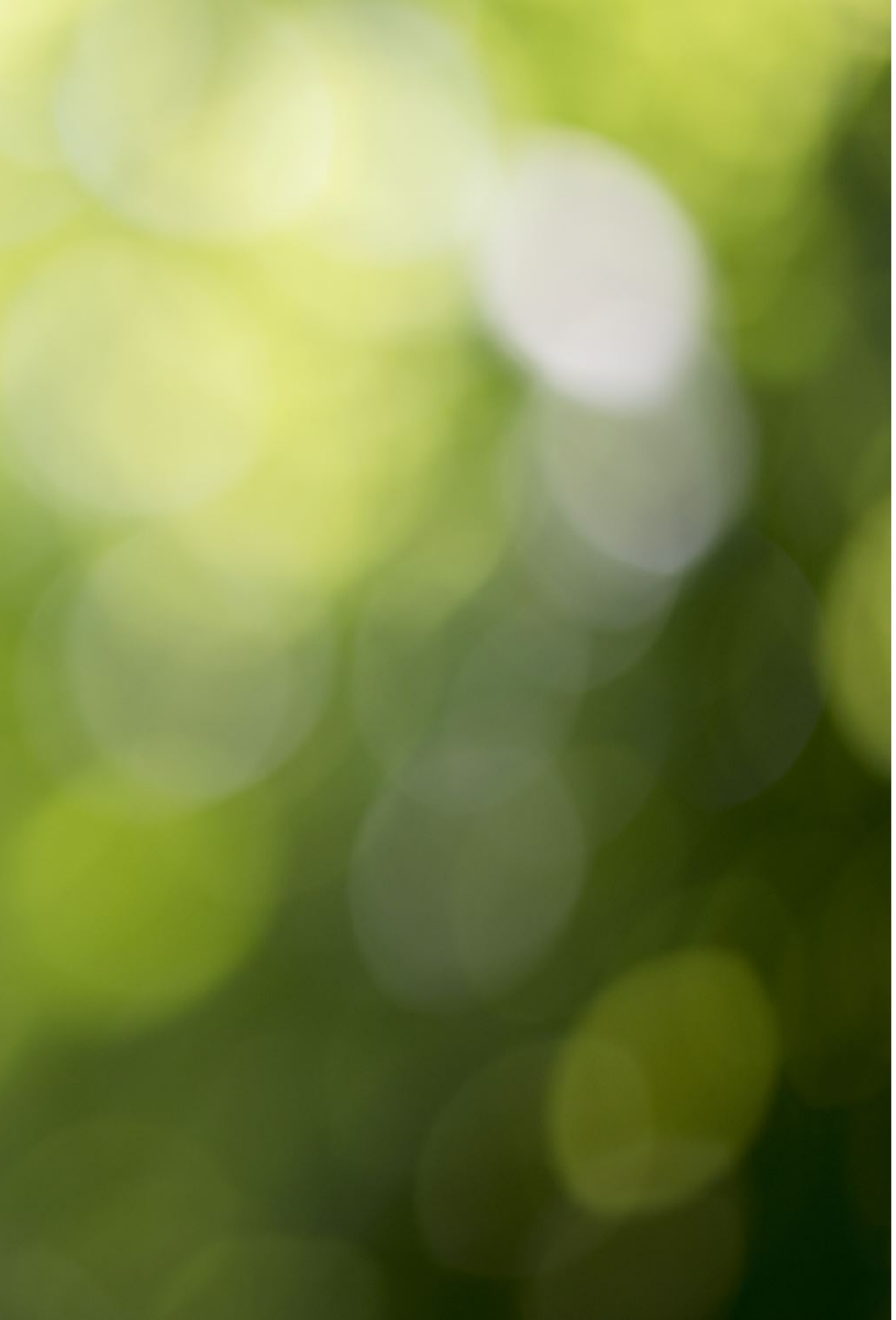
- The first element of the framework is **risk identification,** the process of predicting the key risk outcomes – indicators that something is going wrong in a project.
- For example, if an interim report is not received from part of the project team, the likelihood is that there are problems with that part of the project.

Some particular aspects to consider are:

- *time* – the critical path or critical chain provides one unit for analysis, as do activities where there is uncertainty, particularly where there is novelty involved. Other key areas to check are time plans for the risky activities that might not even be on the critical path at the start but could easily escalate if there are problems;
- *cost* – the estimates have uncertainty attached to them. How good are they – for instance, if the project is a first-timer?
- *quality* – do we have assurance of all our processes or is a key part of the project (e.g. work being carried out by a supplier or customer) outside our control systems?

In addition, it is now common to see two further risk categories added:

- *health and safety* – what are the risks to people or things of activities being carried out by the project?
- *legal* – the level of risk posed by the project to the legal or financial standing of the organisation.



Assumptions /Tahmin, Varsayım

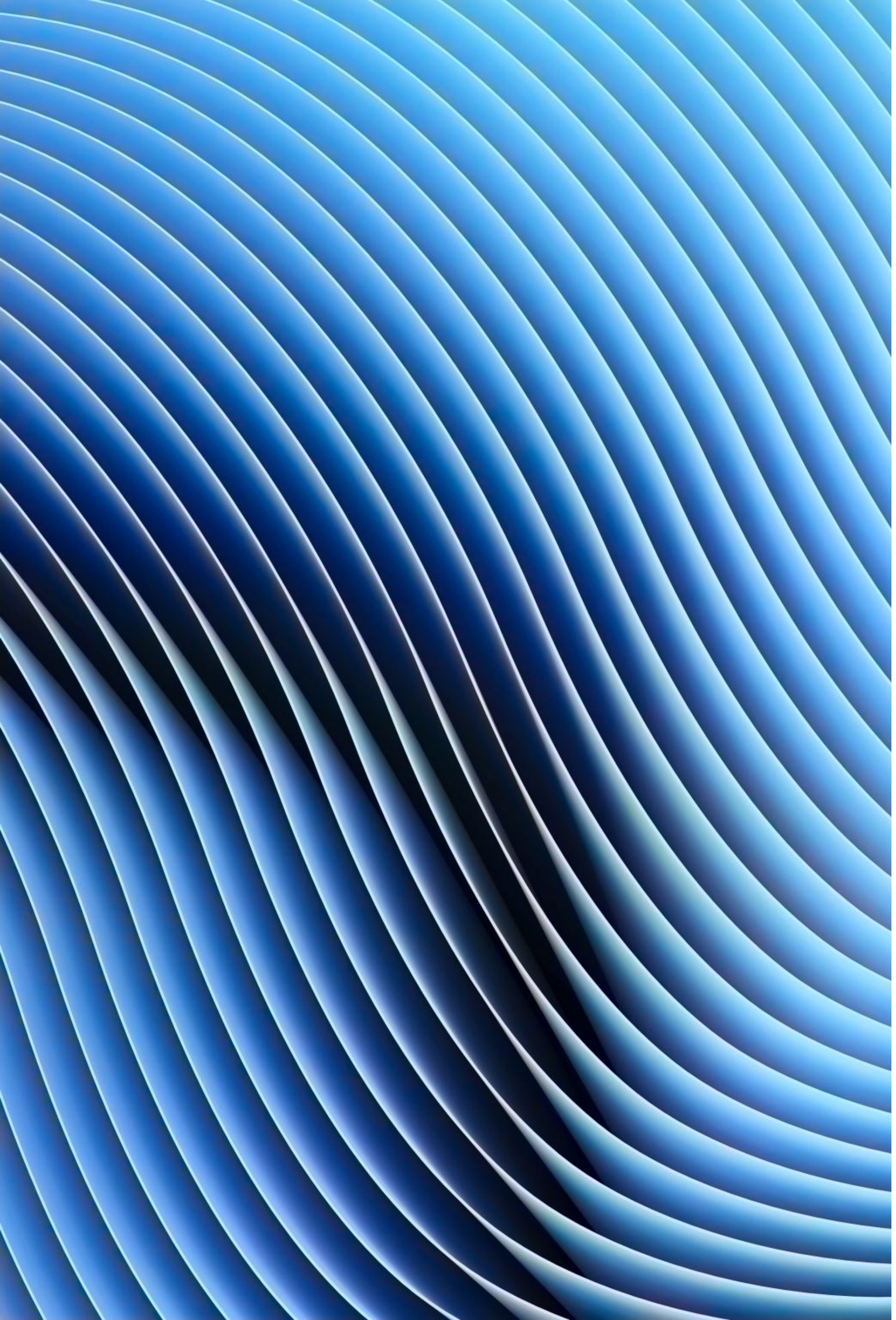
Key assumptions are also worth checking at this point.

A project that will change the way a company operates and is therefore going to save itself some money needs to ensure that it does not simply add the cost somewhere else.

The logistics firm that installed satellite tracking devices on its vehicles because it was useful to keep track of them at all times **did not factor in the costs of operating the satellite system**, which more than outweighed any cost advantage that came from the availability of such information. The system, once installed, was left switched off. **The assumptions of ongoing costs had not been checked.**

Response control/mitigation

- Having identified the risk elements to be managed, some procedures are required to ensure that either the likelihood is reduced of that event occurring or the effects managed or mitigated in some way.
- Yönetilecek risk unsurları belirlendikten sonra, olayın meydana gelme olasılığının azaltılmasını veya etkilerin bir şekilde yönetilmesini veya hafifletilmesini sağlamak için bazı prosedürler gereklidir.



Formal use of risk analysis techniques may be required by:

- company policy;
- clients (especially for defence contracts).

Qualitative and quantitative approaches

The question that we are trying to answer here is: 'Just how risky is an event or activity?' The traditional approach to this includes a number of techniques to assess the level of risk. They have a similar approach of:

- assessing how likely the event is to occur – somewhere on a scale from improbable to highly likely;
- determining the extent of the effect of the event – for instance, is the effect likely to be:
  - critical – will cause the total failure of one or more parts of a project?
  - major – will hold up or increase costs in one or more areas?
  - minor – will cause inconvenience but not set the project back financially or in time?

These can be done in many ways and the techniques described in this section allow for the project manager to determine which of the risk events are going to be managed (it is improbable that all can be managed).

Qualitative approaches

- The majority of risk management activity is based on qualitative data. That is, by gathering peoples' perceptions of the levels of risk involved in a particular activity, some assessment is made of the ranking of that risk for the project.
- Typically, this will assess the likelihood or probability of that risk occurring, and its impact or severity.

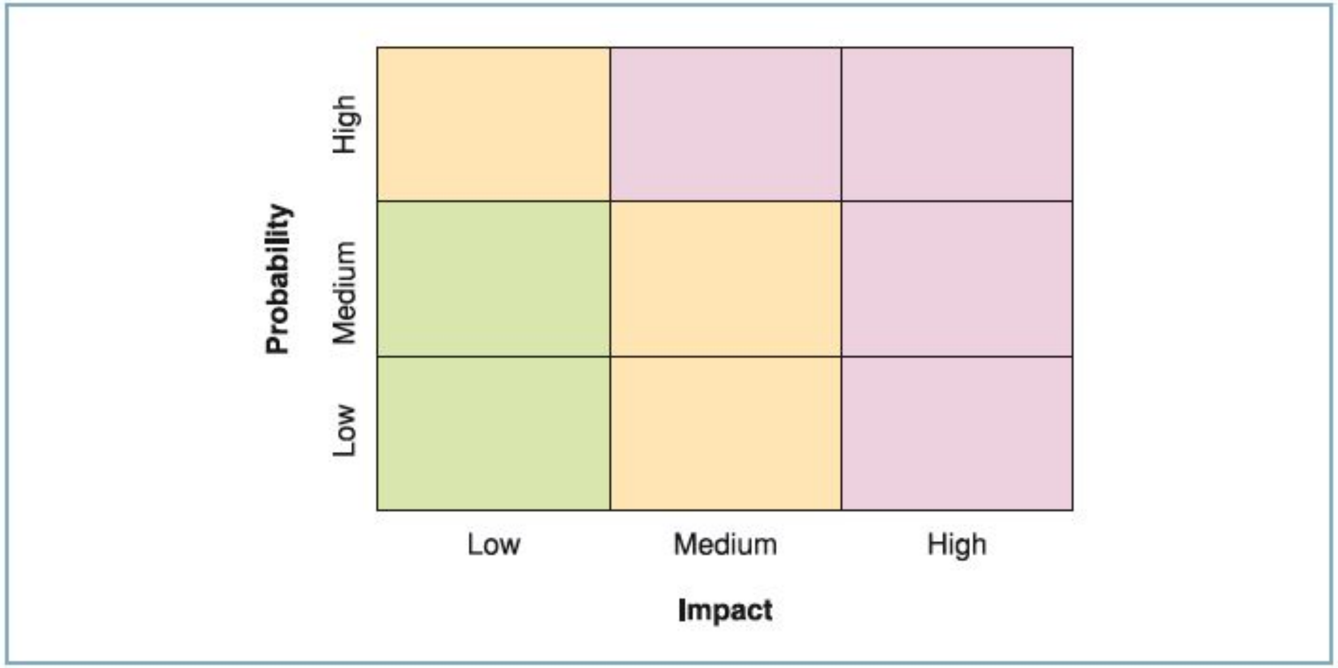


Figure 10.2 Probability impact chart

- An extension of this basic analysis which has been used in industry for many years and is readily applied to projects is failure mode effect analysis (FMEA).
- **This considers three elements of each activity or path through the activities. These are likelihood, severity (as above) and hideability.**

Each of the three factors can be analysed individually, though a practical method is to consider the total risk to be the product of these three elements. Each can be rated on a 1–10 scale and the total risk (the RPN or risk priority number) is:

$$(\textit{likelihood}) \times (\textit{severity}) \times (\textit{hideability})$$

Two activities are analysed as in Table 10.1.

Table 10.1 FMEA analysis

Activity	*Severity*	*Hideability*	*Likelihood*	*RPN*
Development carried out by contractors	8	9	2	144
Development carried out in-house	8	2	7	112

RPN = Risk Priority Number

Criticism

- Whatever criteria are applied, the same criticism of this method prevails – that it takes a list of perceived risks, and for each finds a perceived level of probability and impact.
- Even putting numbers to these does not make it science, or equivalent to quantitative analysis (as below). However, in the absence of other data, this is one approach to establishing the ranking of a risk.

Quantitative approaches

- expected value;
- sensitivity analysis;
- Monte Carlo simulation;
- PERT.

Opportunities management

'ON A RECENT MULTI-MILLION POUND PROJECT, MY TEAM SPENT TWO DAYS TRYING TO REDUCE A £50000 RISK. I WOULD MUCH RATHER THEY HAD SPENT THAT TIME LOOKING TO SEE HOW THE PROJECT COULD YIELD AN EXTRA £50 000 OF BUSINESS BENEFIT.'

(PROJECT DIRECTOR, ROLLS-ROYCE)

Opportunities management

At this stage, it is worth reconsidering the issue, as it is essential that there is a route not only for threats to the project (as is the negative side of risks) but also for the exploitation of opportunities.

There are many approaches to assessing the opportunities. One framework is:

1. *Negative to positive* – where a risk does not materialise, that is a benefit and can be capitalised on, e.g. where a technology proves it can do more than originally thought, the contingency allocated in case it could do less, could be used to develop it further for other applications. Similarly, if a task takes less time than expected, there should be the opportunity to use that early finish benefit to move the rest of the project on faster (as Chapter 7).
2. *Opportunities of response* – where a risk is deemed too high and mitigated, this itself presents opportunities. For instance, using an existing (known) supplier to mitigate the risk of unknown suppliers being involved in the project, does present the opportunity for further learning based on previous experience in running projects.
3. *Random good fortune* – be alert for opportunities presented by breakthrough that could not have been expected. The 3M story above is a good example of this.