



22

Project management

Objectives

The objective of this chapter is to introduce software project management and two important management activities, namely risk management and people management. When you have read the chapter you will:

- know the principal tasks of software project managers;
- have been introduced to the notion of risk management and some of the risks that can arise in software projects;
- understand factors that influence personal motivation and what these might mean for software project managers;
- understand key issues that influence team working, such as team composition, organization, and communication.

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Software project management is an essential part of software engineering. Projects need to be managed because professional software engineering is always subject to organizational budget and schedule constraints. The project manager's job is to ensure that the software project meets and overcomes these constraints as well as delivering high-quality software. Good management cannot guarantee project success. However, bad management usually results in project failure: the software may be delivered late, cost more than originally estimated, or fail to meet the expectations of customers.

The success criteria for project management obviously vary from project to project but, for most projects, important goals are:

1. Deliver the software to the customer at the agreed time.
2. Keep overall costs within budget.
3. Deliver software that meets the customer's expectations.
4. Maintain a happy and well-functioning development team.

These goals are not unique to software engineering but are the goals of all engineering projects. However, software engineering is different from other types of engineering in a number of ways that make software management particularly challenging. Some of these differences are:

1. *The product is intangible* A manager of a shipbuilding or a civil engineering project can see the product being developed. If a schedule slips, the effect on the product is visible—parts of the structure are obviously unfinished. Software is intangible. It cannot be seen or touched. Software project managers cannot see progress by simply looking at the artifact that is being constructed. Rather, they rely on others to produce evidence that they can use to review the progress of the work.
2. *Large software projects are often 'one-off' projects* Large software projects are usually different in some ways from previous projects. Therefore, even managers who have a large body of previous experience may find it difficult to anticipate problems. Furthermore, rapid technological changes in computers and communications can make a manager's experience obsolete. Lessons learned from previous projects may not be transferable to new projects.
3. *Software processes are variable and organization-specific* The engineering process for some types of system, such as bridges and buildings, is well understood. However, software processes vary quite significantly from one organization to another. Although there has been significant progress in process standardization and improvement, we still cannot reliably predict when a particular software process is likely to lead to development problems. This is especially true when the software project is part of a wider systems engineering project.

Because of these issues, it is not surprising that some software projects are late, over budget, and behind schedule. Software systems are often new and technically

innovative. Engineering projects (such as new transport systems) that are innovative often also have schedule problems. Given the difficulties involved, it is perhaps remarkable that so many software projects are delivered on time and to budget!

It is impossible to write a standard job description for a software project manager. The job varies tremendously depending on the organization and the software product being developed. However, most managers take responsibility at some stage for some or all of the following activities:

1. *Project planning* Project managers are responsible for planning, estimating and scheduling project development, and assigning people to tasks. They supervise the work to ensure that it is carried out to the required standards and monitor progress to check that the development is on time and within budget.
2. *Reporting* Project managers are usually responsible for reporting on the progress of a project to customers and to the managers of the company developing the software. They have to be able to communicate at a range of levels, from detailed technical information to management summaries. They have to write concise, coherent documents that abstract critical information from detailed project reports. They must be able to present this information during progress reviews.
3. *Risk management* Project managers have to assess the risks that may affect a project, monitor these risks, and take action when problems arise.
4. *People management* Project managers are responsible for managing a team of people. They have to choose people for their team and establish ways of working that lead to effective team performance.
5. *Proposal writing* The first stage in a software project may involve writing a proposal to win a contract to carry out an item of work. The proposal describes the objectives of the project and how it will be carried out. It usually includes cost and schedule estimates and justifies why the project contract should be awarded to a particular organization or team. Proposal writing is a critical task as the survival of many software companies depends on having enough proposals accepted and contracts awarded. There can be no set guidelines for this task; proposal writing is a skill that you acquire through practice and experience.


In this chapter, I focus on risk management and people management. Project planning is an important topic in its own right, which I discuss in Chapter 23.

22.1 Risk management

Risk management is one of the most important jobs for a project manager. Risk management involves anticipating risks that might affect the project schedule or the quality of the software being developed, and then taking action to avoid these risks

(Hall, 1998; Ould, 1999). You can think of a risk as something that you'd prefer not to have happen. Risks may threaten the project, the software that is being developed, or the organization. There are, therefore, three related categories of risk:

1. *Project risks* Risks that affect the project schedule or resources. An example of a project risk is the loss of an experienced designer. Finding a replacement designer with appropriate skills and experience may take a long time and, consequently, the software design will take longer to complete.
2. *Product risks* Risks that affect the quality or performance of the software being developed. An example of a product risk is the failure of a purchased component to perform as expected. This may affect the overall performance of the system so that it is slower than expected.
3. *Business risks* Risks that affect the organization developing or procuring the software. For example, a competitor introducing a new product is a business risk. The introduction of a competitive product may mean that the assumptions made about sales of existing software products may be unduly optimistic.



Of course, these risk types overlap. If an experienced programmer leaves a project this can be a project risk because, even if they are immediately replaced, the schedule will be affected. It inevitably takes time for a new project member to understand the work that has been done, so they cannot be immediately productive. Consequently, the delivery of the system may be delayed. The loss of a team member can also be a product risk because a replacement may not be as experienced and so could make programming errors. Finally, it can be a business risk because that programmer's experience may be crucial in winning new contracts.

You should record the results of the risk analysis in the project plan along with a consequence analysis, which sets out the consequences of the risk for the project, product, and business. Effective risk management makes it easier to cope with problems and to ensure that these do not lead to unacceptable budget or schedule slippage.

The specific risks that may affect a project depend on the project and the organizational environment in which the software is being developed. However, there are also common risks that are not related to the type of software being developed and these can occur in any project. Some of these common risks are shown in Figure 22.1.

Risk management is particularly important for software projects because of the inherent uncertainties that most projects face. These stem from loosely defined requirements, requirements changes due to changes in customer needs, difficulties in estimating the time and resources required for software development, and differences in individual skills. You have to anticipate risks; understand the impact of these risks on the project, the product, and the business; and take steps to avoid these risks. You may need to draw up contingency plans so that, if the risks do occur, you can take immediate recovery action.

Risk	Affects	Description
Staff turnover	Project	Experienced staff will leave the project before it is finished.
Management change	Project	There will be a change of organizational management with different priorities.
Hardware unavailability	Project	Hardware that is essential for the project will not be delivered on schedule.
Requirements change	Project and product	There will be a larger number of changes to the requirements than anticipated.
Specification delays	Project and product	Specifications of essential interfaces are not available on schedule.
Size underestimate	Project and product	The size of the system has been underestimated.
CASE tool underperformance	Product	CASE tools, which support the project, do not perform as anticipated.
Technology change	Business	The underlying technology on which the system is built is superseded by new technology.
Product competition	Business	A competitive product is marketed before the system is completed.

Figure 22.1
Examples of common
project, product,
and business risks

An outline of the process of risk management is illustrated in Figure 22.2. It involves several stages:

1. *Risk identification* You should identify possible project, product, and business risks.
2. *Risk analysis* You should assess the likelihood and consequences of these risks.
3. *Risk planning* You should make plans to address the risk, either by avoiding it or minimizing its effects on the project.
4. *Risk monitoring* You should regularly assess the risk and your plans for risk mitigation and revise these when you learn more about the risk.

You should document the outcomes of the risk management process in a risk management plan. This should include a discussion of the risks faced by the project, an analysis of these risks, and information on how you propose to manage the risk if it seems likely to be a problem.

The risk management process is an iterative process that continues throughout the project. Once you have drawn up an initial risk management plan, you monitor the situation to detect emerging risks. As more information about the risks becomes available, you have to reanalyze the risks and decide if the risk priority has changed. You may then have to change your plans for risk avoidance and contingency management.

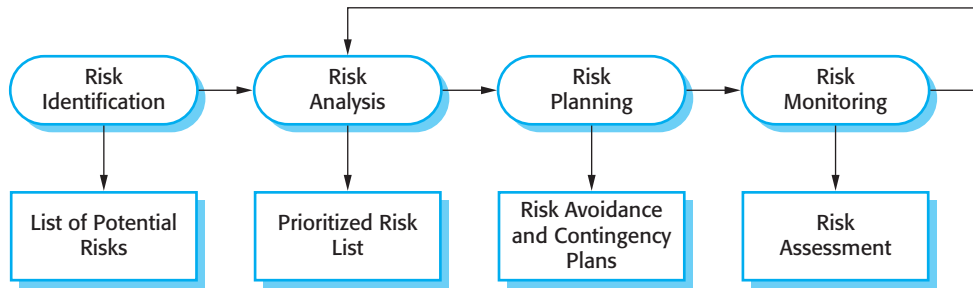


Figure 22.2
The risk
management
process

22.1.1 Risk identification

Risk identification is the first stage of the risk management process. It is concerned with identifying the risks that could pose a major threat to the software engineering process, the software being developed, or the development organization. Risk identification may be a team process where a team get together to brainstorm possible risks. Alternatively, the project manager may simply use his or her experience to identify the most probable or critical risks.

As a starting point for risk identification, a checklist of different types of risk may be used. There are at least six types of risk that may be included in a risk checklist:

1. *Technology risks* Risks that derive from the software or hardware technologies that are used to develop the system.
2. *People risks* Risks that are associated with the people in the development team.
3. *Organizational risks* Risks that derive from the organizational environment where the software is being developed.
4. *Tools risks* Risks that derive from the software tools and other support software used to develop the system.
5. *Requirements risks* Risks that derive from changes to the customer requirements and the process of managing the requirements change.
6. *Estimation risks* Risks that derive from the management estimates of the resources required to build the system.

Figure 22.3 gives some examples of possible risks in each of these categories. When you have finished the risk identification process, you should have a long list of risks that could occur and which could affect the product, the process, and the business. You then need to prune this list to a manageable size. If you have too many risks, it is practically impossible to keep track of all of them.

22.1.2 Risk analysis

During the risk analysis process, you have to consider each identified risk and make a judgment about the probability and seriousness of that risk. There is no easy way to do this. You have to rely on your own judgment and experience of previous projects

Risk type	Possible risks
Technology	The database used in the system cannot process as many transactions per second as expected. (1) Reusable software components contain defects that mean they cannot be reused as planned. (2)
People	It is impossible to recruit staff with the skills required. (3) Key staff are ill and unavailable at critical times. (4) Required training for staff is not available. (5)
Organizational	The organization is restructured so that different management are responsible for the project. (6) Organizational financial problems force reductions in the project budget. (7)
Tools	The code generated by software code generation tools is inefficient. (8) Software tools cannot work together in an integrated way. (9)
Requirements	Changes to requirements that require major design rework are proposed. (10) Customers fail to understand the impact of requirements changes. (11)
Estimation	The time required to develop the software is underestimated. (12) The rate of defect repair is underestimated. (13) The size of the software is underestimated. (14)

Figure 22.3
Examples of different
types of risks

and the problems that arose in them. It is not possible to make precise, numeric assessment of the probability and seriousness of each risk. Rather, you should assign the risk to one of a number of bands:

1. The probability of the risk might be assessed as very low (< 10%), low (10–25%), moderate (25–50%), high (50–75%), or very high (> 75%).
2. The effects of the risk might be assessed as catastrophic (threaten the survival of the project), serious (would cause major delays), tolerable (delays are within allowed contingency), or insignificant.

You should then tabulate the results of this analysis process using a table ordered according to the seriousness of the risk. Figure 22.4 illustrates this for the risks that I have identified in Figure 22.3. Obviously, the assessment of probability and seriousness is arbitrary here. To make this assessment, you need detailed information about the project, the process, the development team, and the organization.

Of course, both the probability and the assessment of the effects of a risk may change as more information about the risk becomes available and as risk management plans are implemented. Therefore, you should update this table during each iteration of the risk process.

Once the risks have been analyzed and ranked, you should assess which of these risks are most significant. Your judgment must depend on a combination of the probability of the risk arising and the effects of that risk. In general, catastrophic risks should always be considered, as should all serious risks that have more than a moderate probability of occurrence.

Risk	Probability	Effects
Organizational financial problems force reductions in the project budget (7).	Low	Catastrophic
It is impossible to recruit staff with the skills required for the project (3).	High	Catastrophic
Key staff are ill at critical times in the project (4).	Moderate	Serious
Faults in reusable software components have to be repaired before these components are reused. (2).	Moderate	Serious
Changes to requirements that require major design rework are proposed (10).	Moderate	Serious
The organization is restructured so that different management are responsible for the project (6).	High	Serious
The database used in the system cannot process as many transactions per second as expected (1).	Moderate	Serious
The time required to develop the software is underestimated (12).	High	Serious
Software tools cannot be integrated (9).	High	Tolerable
Customers fail to understand the impact of requirements changes (11).	Moderate	Tolerable
Required training for staff is not available (5).	Moderate	Tolerable
The rate of defect repair is underestimated (13).	Moderate	Tolerable
The size of the software is underestimated (14).	High	Tolerable
Code generated by code generation tools is inefficient (8).	Moderate	Insignificant

Figure 22.4 Risk types and examples

Boehm (1988) recommends identifying and monitoring the top 10 risks, but I think that this figure is rather arbitrary. The right number of risks to monitor must depend on the project. It might be 5 or it might be 15. However, the number of risks chosen for monitoring should be manageable. A very large number of risks would simply require too much information to be collected. From the risks identified in Figure 22.4, it is appropriate to consider the 8 risks that have catastrophic or serious consequences (Figure 22.5).

22.1.3 Risk planning

The risk planning process considers each of the key risks that have been identified, and develops strategies to manage these risks. For each of the risks, you have to think of actions that you might take to minimize the disruption to the project if the problem identified in the risk occurs. You also should think about information that you might need to collect while monitoring the project so that problems can be anticipated.

Risk	Strategy
Organizational financial problems	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business and presenting reasons why cuts to the project budget would not be cost-effective.
Recruitment problems	Alert customer to potential difficulties and the possibility of delays; investigate buying-in components.
Staff illness	Reorganize team so that there is more overlap of work and people therefore understand each other's jobs.
Defective components	Replace potentially defective components with bought-in components of known reliability.
Requirements changes	Derive traceability information to assess requirements change impact; maximize information hiding in the design.
Organizational restructuring	Prepare a briefing document for senior management showing how the project is making a very important contribution to the goals of the business.
Database performance	Investigate the possibility of buying a higher-performance database.
Underestimated development time	Investigate buying-in components; investigate use of a program generator.

Figure 22.5 Strategies to help manage risk

Again, there is no simple process that can be followed for contingency planning. It relies on the judgment and experience of the project manager.

Figure 22.5 shows possible risk management strategies that have been identified for the key risks (i.e., those that are serious or intolerable) shown in Figure 22.4. These strategies fall into three categories:

1. *Avoidance strategies* Following these strategies means that the probability that the risk will arise will be reduced. An example of a risk avoidance strategy is the strategy for dealing with defective components shown in Figure 22.5.
2. *Minimization strategies* Following these strategies means that the impact of the risk will be reduced. An example of a risk minimization strategy is the strategy for staff illness shown in Figure 22.5.
3. *Contingency plans* Following these strategies means that you are prepared for the worst and have a strategy in place to deal with it. An example of a contingency strategy is the strategy for organizational financial problems that I have shown in Figure 22.5.

You can see a clear analogy here with the strategies used in critical systems to ensure reliability, security, and safety, where you must avoid, tolerate, or recover from failures. Obviously, it is best to use a strategy that avoids the risk. If this is not possible, you should use a strategy that reduces the chances that the risk will have serious effects. Finally, you should have strategies in place to cope with the risk if it arises. These should reduce the overall impact of a risk on the project or product.

Risk type	Potential indicators
Technology	Late delivery of hardware or support software; many reported technology problems.
People	Poor staff morale; poor relationships amongst team members; high staff turnover.
Organizational	Organizational gossip; lack of action by senior management.
Tools	Reluctance by team members to use tools; complaints about CASE tools; demands for higher-powered workstations.
Requirements	Many requirements change requests; customer complaints.
Estimation	Failure to meet agreed schedule; failure to clear reported defects.

Figure 22.6 Risk indicators

22.1.4 Risk monitoring

Risk monitoring is the process of checking that your assumptions about the product, process, and business risks have not changed. You should regularly assess each of the identified risks to decide whether or not that risk is becoming more or less probable. You should also think about whether or not the effects of the risk have changed. To do this, you have to look at other factors, such as the number of requirements change requests, which give you clues about the risk probability and its effects. These factors are obviously dependent on the types of risk. Figure 22.6 gives some examples of factors that may be helpful in assessing these risk types.

You should monitor risks regularly at all stages in a project. At every management review, you should consider and discuss each of the key risks separately. You should decide if the risk is more or less likely to arise and if the seriousness and consequences of the risk have changed.

22.2 Managing people

The people working in a software organization are its greatest assets. It costs a lot to recruit and retain good people and it is up to software managers to ensure that the organization gets the best possible return on its investment. In successful companies and economies, this is achieved when people are respected by the organization and are assigned responsibilities that reflect their skills and experience.

It is important that software project managers understand the technical issues that influence the work of software development. Unfortunately, however, good software engineers are not necessarily good people managers. Software engineers often have strong technical skills but may lack the softer skills that enable them to

motivate and lead a project development team. As a project manager, you should be aware of the potential problems of people management and should try to develop people management skills.

In my view, there are four critical factors in people management:

1. *Consistency* People in a project team should all be treated in a comparable way. No one expects all rewards to be identical but people should not feel that their contribution to the organization is undervalued.
2. *Respect* Different people have different skills and managers should respect these differences. All members of the team should be given an opportunity to make a contribution. In some cases, of course, you will find that people simply don't fit into a team and they cannot continue, but it is important not to jump to conclusions about this at an early stage in the project.
3. *Inclusion* People contribute effectively when they feel that others listen to them and take account of their proposals. It is important to develop a working environment where all views, even those of the most junior staff, are considered.
4. *Honesty* As a manager, you should always be honest about what is going well and what is going badly in the team. You should also be honest about your level of technical knowledge and willing to defer to staff with more knowledge when necessary. If you try to cover up ignorance or problems you will eventually be found out and will lose the respect of the group.

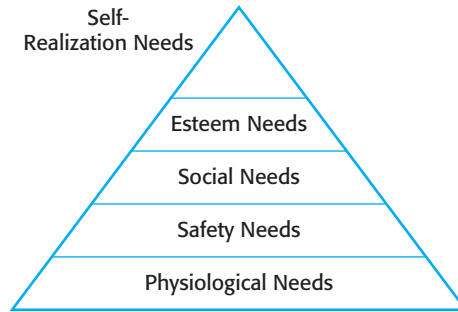
People management, in my view, is something that has to be based on experience, rather than learned from a book. My aim in this section and the following section on teamwork is simply to introduce some of the most important people and team management problems that affect software project management. I hope the material here will sensitize you to some of the problems that managers may encounter when dealing with teams of technically talented individuals.

22.2.1 Motivating people

As a project manager, you need to motivate the people that work with you so that they contribute to the best of their abilities. Motivation means organizing the work and the working environment to encourage people to work as effectively as possible. If people are not motivated, they will not be interested in the work they are doing. They will work slowly, be more likely to make mistakes, and will not contribute to the broader goals of the team or the organization.

To provide this encouragement, you should understand a little about what motivates people. Maslow (1954) suggests that people are motivated by satisfying their needs. These needs are arranged in a series of levels, as shown in Figure 22.7. The lower levels of this hierarchy represent fundamental needs for food, sleep, and so on, and the need to feel secure in an environment. Social needs are concerned with the need to feel part of a social grouping. Esteem needs represent the need to feel

Figure 22.7 Human needs hierarchy



respected by others, and self-realization needs are concerned with personal development. People need to satisfy lower-level needs like hunger before the more abstract, higher-level needs.

People working in software development organizations are not usually hungry or thirsty or physically threatened by their environment. Therefore, making sure that people's social, esteem, and self-realization needs are satisfied is most important from a management point of view.

1. To satisfy social needs, you need to give people time to meet their co-workers and provide places for them to meet. This is relatively easy when all of the members of a development team work in the same place but, increasingly, team members are not located in the same building or even the same town or state. They may work for different organizations or from home most of the time.

Social networking systems and teleconferencing can be used to facilitate communications but my experience with electronic systems is that they are most effective once people know each other. You therefore need to arrange some face-to-face meetings early in the project so that people can directly interact with other members of the team. Through this direct interaction, people become part of a social group and accept the goals and priorities of that group.

2. To satisfy esteem needs, you need to show people that they are valued by the organization. Public recognition of achievements is a simple yet effective way of doing this. Obviously, people must also feel that they are paid at a level that reflects their skills and experience.
3. Finally, to satisfy self-realization needs, you need to give people responsibility for their work, assign them demanding (but not impossible) tasks, and provide a training programme where people can develop their skills. Training is an important motivating influence as people like to gain new knowledge and learn new skills.

In Figure 22.8, I illustrate a problem of motivation that managers often have to face. In this example, a competent group member loses interest in the work and in

Case study: Motivation

Alice is a software project manager working in a company that develops alarm systems. This company wishes to enter the growing market of assistive technology to help elderly and disabled people live independently. Alice has been asked to lead a team of 6 developers than can develop new products based around the company's alarm technology.

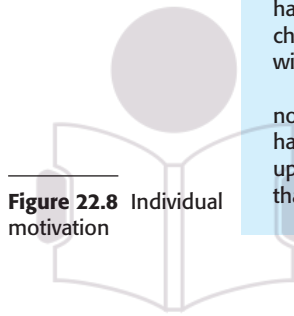
Alice's assistive technology project starts well. Good working relationships develop within the team and creative new ideas are developed. The team decides to develop a peer-to-peer messaging system using digital televisions linked to the alarm network for communications. However, some months into the project, Alice notices that Dorothy, a hardware design expert, starts coming into work late, the quality of her work deteriorates and, increasingly, that she does not appear to be communicating with other members of the team.

Alice talks about the problem informally with other team members to try to find out if Dorothy's personal circumstances have changed, and if this might be affecting her work. They don't know of anything, so Alice decides to talk with Dorothy to try to understand the problem.

After some initial denials that there is a problem, Dorothy admits that she has lost interest in the job. She expected that she would be able to develop and use her hardware interfacing skills. However, because of the product direction that has been chosen, she has little opportunity for this. Basically, she is working as a C programmer with other team members.

Although she admits that the work is challenging, she is concerned that she is not developing her interfacing skills. She is worried that finding a job that involves hardware interfacing will be difficult after this project. Because she does not want to upset the team by revealing that she is thinking about the next project, she has decided that it is best to minimize conversation with them.

Figure 22.8 Individual motivation



the group as a whole. The quality of her work falls and becomes unacceptable. This situation has to be dealt with quickly. If you don't sort out the problem, the other group members will become dissatisfied and feel that they are doing an unfair share of the work.

In this example, Alice tries to find out if Dorothy's personal circumstances could be the problem. Personal difficulties commonly affect motivation because people cannot concentrate on their work. You may have to give them time and support to resolve these issues, although you also have to make it clear that they still have a responsibility to their employer.

Dorothy's motivation problem is one that is quite common when projects develop in an unexpected direction. People who expect to do one type of work may end up doing something completely different. This becomes a problem when team members want to develop their skills in a way that is different from that taken by the project. In those circumstances, you may decide that the team member should leave the team and find opportunities elsewhere. In this example, however, Alice decides to try to convince Dorothy that broadening her experience is a positive career step. She gives Dorothy more design autonomy and organizes training courses in software engineering that will give her more opportunities after her current project has finished.



The People Capability Maturity Model

The People Capability Maturity Model (P-CMM) is a framework for assessing how well organizations manage the development of their staff. It highlights best practice in people management and provides a basis for organizations to improve their people management processes.

<http://www.SoftwareEngineering-9.com/Web/Management/P-CMM.html>

Maslow's model of motivation is helpful up to a point but I think that a problem with it is that it takes an exclusively personal viewpoint on motivation. It does not take adequate account of the fact that people feel themselves to be part of an organization, a professional group, and one or more cultures. This is not simply a question of satisfying social needs—people can be motivated through helping a group achieve shared goals.

Being a member of a cohesive group is highly motivating for most people. People with fulfilling jobs often like to go to work because they are motivated by the people they work with and the work that they do. Therefore, as well as thinking about individual motivation you also have to think about how a group as a whole can be motivated to achieve the organization's goals. I discuss group management issues in the next section.

Personality type also influences motivation. Bass and Duntzman (1963) classify professionals into three types:

1. Task-oriented people, who are motivated by the work they do. In software engineering, these are people who are motivated by the intellectual challenge of software development.
2. Self-oriented people, who are principally motivated by personal success and recognition. They are interested in software development as a means of achieving their own goals. This does not mean that these people are selfish and think only of their own concerns. Rather, they often have longer-term goals, such as career progression, that motivate them and they wish to be successful in their work to help realize these goals.
3. Interaction-oriented people, who are motivated by the presence and actions of co-workers. As software development becomes more user-centered, interaction-oriented individuals are becoming more involved in software engineering.

Interaction-oriented personalities usually like to work as part of a group, whereas task-oriented and self-oriented people usually prefer to act as individuals. Women are more likely to be interaction-oriented than men. They are often more effective communicators. I discuss the mix of these different personality types in groups in the case study in Figure 22.10.

Each individual's motivation is made up of elements of each class but one type of motivation is usually dominant at any one time. However, individuals can change. For example, technical people who feel they are not being properly rewarded can become self-oriented and put personal interests before technical concerns. If a group works particularly well, self-oriented people can become more interaction-oriented.

22.3 Teamwork

Most professional software is developed by project teams that range in size from two to several hundred people. However, as it is clearly impossible for everyone in a large group to work together on a single problem, large teams are usually split into a number of groups. Each group is responsible for developing part of the overall system. As a general rule, software engineering project groups should not have more than 10 members. When small groups are used, communication problems are reduced. Everyone knows everyone else and the whole group can get around a table for a meeting to discuss the project and the software that they are developing.

Putting together a group that has the right balance of technical skills, experience, and personalities is a critical management task. However, successful groups are more than simply a collection of individuals with the right balance of skills. A good group is cohesive and has a team spirit. The people involved are motivated by the success of the group as well as by their own personal goals.

In a cohesive group, members think of the group as more important than the individuals who are group members. Members of a well-led, cohesive group are loyal to the group. They identify with group goals and other group members. They attempt to protect the group, as an entity, from outside interference. This makes the group robust and able to cope with problems and unexpected situations.

The benefits of creating a cohesive group are:

1. *The group can establish its own quality standards* Because these standards are established by consensus, they are more likely to be observed than external standards imposed on the group.
2. *Individuals learn from and support each other* People in the group learn from each other. Inhibitions caused by ignorance are minimized as mutual learning is encouraged.
3. *Knowledge is shared* Continuity can be maintained if a group member leaves. Others in the group can take over critical tasks and ensure that the project is not unduly disrupted.
4. *Refactoring and continual improvement is encouraged* Group members work collectively to deliver high-quality results and fix problems, irrespective of the individuals who originally created the design or program.

Case study: Team spirit

Alice, an experienced project manager, understands the importance of creating a cohesive group. As they are developing a new product, she takes the opportunity of involving all group members in the product specification and design by getting them to discuss possible technology with elderly members of their families. She also encourages them to bring these family members to meet other members of the development group.

Alice also arranges monthly lunches for everyone in the group. These lunches are an opportunity for all team members to meet informally, talk around issues of concern, and get to know each other. At the lunch, Alice tells the group what she knows about organizational news, policies, strategies, and so forth. Each team member then briefly summarizes what they have been doing and the group discusses a general topic, such as new product ideas from elderly relatives.

Every few months, Alice organizes an 'away day' for the group where the team spends two days on 'technology updating'. Each team member prepares an update on a relevant technology and presents it to the group. This is an off-site meeting in a good hotel and plenty of time is scheduled for discussion and social interaction.

Figure 22.9 Group cohesion

Good project managers should always try to encourage group cohesiveness. They may organize social events for group members and their families, try to establish a sense of group identity by naming the group and establishing a group identity and territory, or they may get involved in explicit group-building activities such as sports and games.

One of the most effective ways of promoting cohesion is to be inclusive. This means that you should treat group members as responsible and trustworthy, and make information freely available. Sometimes, managers feel that they cannot reveal certain information to everyone in the group. This invariably creates a climate of mistrust. Simple information exchange is an effective way of making people feel valued and that they are part of a group.

You can see an example of this in the case study in Figure 22.9. Alice arranges regular informal meetings where she tells the other group members what is going on. She makes a point of involving people in the product development by asking them to come up with new ideas derived from their own family experiences. The 'away days' are also good ways of promoting cohesion—people relax together while they help each other learn about new technologies.

Whether or not a group is effective depends, to some extent, on the nature of the project and the organization doing the work. If an organization is in a state of turmoil with constant reorganizations and job insecurity, it is very difficult for team members to focus on software development. However, apart from project and organizational issues, there are three generic factors that affect team working:

1. *The people in the group* You need a mix of people in a project group as software development involves diverse activities such as negotiating with clients, programming, testing, and documentation.

2. *The group organization* A group should be organized so that individuals can contribute to the best of their abilities and tasks can be completed as expected.
3. *Technical and managerial communications* Good communications between group members, and between the software engineering team and other project stakeholders, is essential.

As with all management issues, getting the right team cannot guarantee project success. Too many other things can go wrong, including changes to the business and the business environment. However, if you don't pay attention to group composition, organization, and communications, you increase the likelihood that your project will run into difficulties.

22.3.1 Selecting group members



A manager or team leader's job is to create a cohesive group and organize their group so that they can work together effectively. This involves creating a group with the right balance of technical skills and personalities, and organizing that group so that the members work together effectively. Sometimes, people are hired from outside the organization; more often, however, software engineering groups are put together from current employees who have experience on other projects. However, managers rarely have a completely free hand in team selection. They often have to use the people who are available in the company, even when they may not be the ideal people for the job.

As I discussed in Section 22.2.1, many software engineers are motivated primarily by their work. Software development groups, therefore, are often composed of people who have their own ideas about how technical problems should be solved. This is reflected in regularly reported problems of interface standards being ignored, systems being redesigned as they are coded, unnecessary system embellishments, and so on.

A group that has complementary personalities may work better than a group that is selected solely on technical ability. People who are motivated by the work are likely to be the strongest technically. People who are self-oriented will probably be best at pushing the work forward to finish the job. People who are interaction-oriented help facilitate communications within the group. I think that it is particularly important to have interaction-oriented people in a group. They like to talk to people and can detect tensions and disagreements at an early stage, before these have a serious impact on the group.

In the case study in Figure 22.10, I have suggested how Alice, the project manager, has tried to create a group with complementary personalities. This particular group has a good mix of interaction- and task-oriented people but I have already discussed, in Figure 22.8, how Dorothy's self-oriented personality has caused problems because she has not been doing the work that she expected. Fred's part-time role in the group as a domain expert might also be a problem. He is mostly interested in

Case study: Group composition

In creating a group for assistive technology development, Alice is aware of the importance of selecting members with complementary personalities. When interviewing potential group members, she tried to assess whether they were task-oriented, self-oriented, or interaction-oriented. She felt that she was primarily a self-oriented type because she considered the project to be a way of getting noticed by senior management and possibly promoted. She therefore looked for one or perhaps two interaction-oriented personalities, with task-oriented individuals to complete the team. The final assessment that she arrived at was:

Alice—self-oriented
 Brian—task-oriented
 Bob—task-oriented
 Carol—interaction-oriented
 Dorothy—self-oriented
 Ed—interaction-oriented
 Fred—task-oriented

Figure 22.10 Group composition

technical challenges, so he may not interact well with other group members. The fact that he is not always part of the team means that he may not relate well to the team's goals.

It is sometimes impossible to choose a group with complementary personalities. If this is the case, the project manager has to control the group so that individual goals do not take precedence over organizational and group objectives. This control is easier to achieve if all group members participate in each stage of the project. Individual initiative is most likely when group members are given instructions without being aware of the part that their task plays in the overall project.

For example, say a software engineer is given a program design for coding and notices what appears to be possible improvements that could be made to the design. If he or she implements these improvements without understanding the rationale for the original design, any changes, though well intentioned, might have adverse implications for other parts of the system. If all the members of the group are involved in the design from the start, they will understand why design decisions have been made. They may then identify with these decisions rather than oppose them.

22.3.2 Group organization

The way that a group is organized affects the decisions that are made by that group, the ways that information is exchanged, and the interactions between the development group and external project stakeholders. Important organizational questions for project managers include:

1. Should the project manager be the technical leader of the group? The technical leader or system architect is responsible for the critical technical decisions made



Hiring the right people

Project managers are often responsible for selecting the people in the organization who will join their software engineering team. Getting the best possible people in this process is very important as poor selection decisions may be a serious risk to the project.

Key factors that should influence the selection of staff are education and training, application domain and technology experience, communication ability, adaptability, and problem-solving ability.

<http://www.SoftwareEngineering-9.com/Web/Management/Selection.html>

during software development. Sometimes, the project manager has the skill and experience to take on this role. However, for large projects, it is best to appoint a senior engineer to be the project architect, who will take responsibility for technical leadership.

2. Who will be involved in making critical technical decisions, and how will these be made? Will decisions be made by the system architect, the project manager, or by reaching consensus amongst a wider range of team members?
3. How will interactions with external stakeholders and senior company management be handled? In many cases, the project manager will be responsible for these interactions, assisted by the system architect if there is one. However, an alternative organizational model is to create a dedicated role concerned with external liaison, and appoint someone with appropriate interaction skills to that role.
4. How can groups integrate people who are not colocated? It is now common for groups to include members from different organizations and people to work from home as well as in a shared office. This has to be taken into account in group decision-making processes.
5. How can knowledge be shared across the group? Group organization affects information sharing as certain methods of organization are better for sharing than others. However, you should avoid too much information sharing as people become overloaded and excessive information distracts them from their work.

Small programming groups are usually organized in a fairly informal way. The group leader gets involved in the software development with the other group members. In an informal group, the work to be carried out is discussed by the group as a whole, and tasks are allocated according to ability and experience. More senior group members may be responsible for the architectural design. However, detailed design and implementation is the responsibility of the team member who is allocated to a particular task.

Extreme programming groups (Beck, 2000) are always informal groups. XP enthusiasts claim that formal structure inhibits information exchange. In XP, many

decisions that are usually seen as management decisions (such as decisions on schedule) are devolved to group members. Programmers work together in pairs to develop code and take joint responsibility for the programs that are developed.

Informal groups can be very successful, particularly when most group members are experienced and competent. Such a group makes decisions by consensus, which improves cohesiveness and performance. However, if a group is composed mostly of inexperienced or incompetent members, informality can be a hindrance because no definite authority exists to direct the work, causing a lack of coordination between group members and, possibly, eventual project failure.

Hierarchical groups are groups that have a hierarchical structure with the group leader at the top of the hierarchy. He or she has more formal authority than the group members and so can direct their work. There is a clear organizational structure and decisions are made towards the top of the hierarchy and implemented by people lower down the hierarchy. Communications are primarily instructions from senior staff and there is relatively little ‘upward’ communication from the lower levels to the upper levels in the hierarchy.

This approach can work well when a well-understood problem can be easily broken into subproblems with subproblem solutions developed in different parts of the hierarchy. In those situations, relatively little communication across the hierarchy is required. However, such situations are relatively rare in software engineering for the following reasons:

1. Changes to the software often require changes to several parts of the system and this requires discussion and negotiation at all levels in the hierarchy.
2. Software technologies change so fast that more junior staff often know more about the technology than experienced staff. Top-down communications may mean that the project manager does not find out about the opportunities of using new technologies. More junior staff may become frustrated because of what they see as old-fashioned technologies being used for development.

Democratic and hierarchic group organizations do not formally recognize that there may be very large differences in technical ability between group members. The best programmers may be up to 25 times more productive as the worst programmers. It makes sense to use the best people in the most effective way and to provide them with as much support as possible. An early organizational model that was intended to provide this support was the chief programmer team.

To make the most effective use of highly skilled programmers, Baker (1972) and others (Aron, 1974; Brooks, 1975) suggested that teams should be built around an individual, highly skilled chief programmer. The underlying principle of the chief programmer team is that skilled and experienced staff should be responsible for all software development. They should not be concerned with routine matters and should have good technical and administrative support for their work. They should focus on the software to be developed and not spend a lot of time in external meetings.



The physical work environment

The environment in which people work affects both group communications and individual productivity. Individual workspaces are better for concentration on detailed technical work as people are less likely to be distracted by interruptions. However, shared workspaces are better for communications. A well-designed work environment takes both of these needs into account.

<http://www.SoftwareEngineering-9.com/Web/Management/workspace.html>

However, the chief programmer team organization is, in my view, overdependent on the chief programmer and their assistant. Other team members who are not given sufficient responsibility may become demotivated because they feel their skills are underused. They do not have the information to cope if things go wrong and are not given the opportunity to participate in decision making. There are significant project risks associated with this group organization and these may outweigh any benefits that this kind of organization might bring.

22.3.3 Group communications

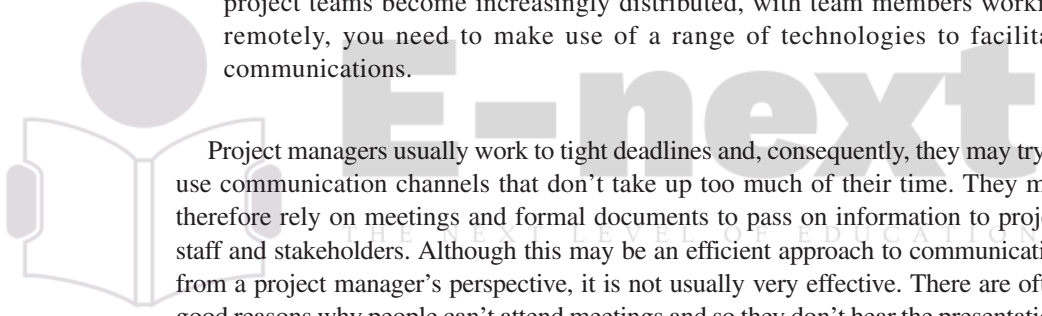
It is absolutely essential that group members communicate effectively and efficiently with each other and with other project stakeholders. Group members must exchange information on the status of their work, the design decisions that have been made, and changes to previous design decisions. They have to resolve problems that arise with other stakeholders and inform these stakeholders of changes to the system, the group, and delivery plans. Good communication also helps strengthen group cohesiveness. Group members come to understand the motivations, strengths, and weaknesses of other people in the group.

The effectiveness and efficiency of communications is influenced by:

1. *Group size* As a group gets bigger, it gets harder for members to communicate effectively. The number of one-way communication links is $n * (n - 1)$, where n is the group size, so, with a group of eight members, there are 56 possible communication pathways. This means that it is quite possible that some people will rarely communicate with each other. Status differences between group members mean that communications are often one-way. Managers and experienced engineers tend to dominate communications with less experienced staff, who may be reluctant to start a conversation or make critical remarks.
2. *Group structure* People in informally structured groups communicate more effectively than people in groups with a formal, hierarchical structure. In hierarchical groups, communications tend to flow up and down the hierarchy. People at the same level may not talk to each other. This is a particular problem in a

large project with several development groups. If people working on different subsystems only communicate through their managers, then there are more likely to be delays and misunderstandings.

3. *Group composition* People with the same personality types (discussed in Section 22.2) may clash and, as a result, communications can be inhibited. Communication is also usually better in mixed-sex groups (Marshall and Heslin, 1975) than in single-sex groups. Women are often more interaction-oriented than men and may act as interaction controllers and facilitators for the group.
4. *The physical work environment* The organization of the workplace is a major factor in facilitating or inhibiting communications. See the book's webpage for more information.
5. *The available communication channels* There are many different forms of communication—face-to-face, e-mail messages, formal documents, telephone, and Web 2.0 technologies such as social networking and wikis. As project teams become increasingly distributed, with team members working remotely, you need to make use of a range of technologies to facilitate communications.



Project managers usually work to tight deadlines and, consequently, they may try to use communication channels that don't take up too much of their time. They may therefore rely on meetings and formal documents to pass on information to project staff and stakeholders. Although this may be an efficient approach to communication from a project manager's perspective, it is not usually very effective. There are often good reasons why people can't attend meetings and so they don't hear the presentation. Long documents are often never read because readers don't know if the documents are relevant. When several versions of the same document are produced, readers find it difficult to keep track of the changes.

Effective communication is achieved when communications are two way, and the people involved can discuss issues and information and establish a common understanding of proposals and problems. This can be done through meetings, although these are often dominated by powerful personalities. It is sometimes impractical to arrange meetings at short notice. More and more project teams include remote members, which also makes meetings more difficult.

To counter these problems, you may make use of web technologies such as wikis and blogs to support information exchange. Wikis support the collaborative creation and editing of documents, and blogs support threaded discussions about questions and comments made by group members. Wikis and blogs allow project members and external stakeholders to exchange information, irrespective of their location. They help manage information and keep track of discussion threads, which often become confusing when conducted by e-mail. You can also use instant messaging and teleconferences, which can be easily arranged, to resolve issues that need discussion.

KEY POINTS

- Good software project management is essential if software engineering projects are to be developed on schedule and within budget.
- Software management is distinct from other engineering management. Software is intangible. Projects may be novel or innovative so there is no body of experience to guide their management. Software processes are not as mature as traditional engineering processes.
- Risk management is now recognized as one of the most important project management tasks.
- Risk management involves identifying and assessing major project risks to establish the probability that they will occur and the consequences for the project if that risk does arise. You should make plans to avoid, manage, or deal with likely risks if or when they arise.
- People are motivated by interaction with other people, the recognition of management and their peers, and by being given opportunities for personal development.
- Software development groups should be fairly small and cohesive. The key factors that influence the effectiveness of a group are the people in that group, the way that it is organized, and the communication between group members.
- Communications within a group are influenced by factors such as the status of group members, the size of the group, the gender composition of the group, personalities, and available communication channels.

FURTHER READING

The Mythical Man Month (Anniversary Edition). The problems of software management remain largely unchanged since the 1960s and this is one of the best books on the topic. An interesting and readable account of the management of one of the first very large software projects, the IBM OS/360 operating system. The anniversary edition (published 20 years after the original edition in 1975) includes other classic papers by Brooks. (F. P. Brooks, 1995, Addison-Wesley.)

Software Project Survival Guide. This is a very pragmatic account of software management that contains good practical advice for project managers with a software engineering background. It is easy to read and understand. (S. McConnell, 1998, Microsoft Press.)

Peopleware: Productive Projects and Teams, 2nd edition. This is a new edition of the classic book on the importance of treating people properly when managing software projects. It is one of the few books that recognizes the importance of the place where people work. Strongly recommended. (T. DeMarco and T. Lister, 1999, Dorset House.)

Waltzing with Bears: Managing Risk on Software Projects. A very practical and easy-to-read introduction to risks and risk management. (T. DeMarco and T. Lister, 2003, Dorset House.)

EXERCISES

- 22.1. Explain why the intangibility of software systems poses special problems for software project management.
- 22.2. Explain why the best programmers do not always make the best software managers. You may find it helpful to base your answer on the list of management activities in Section 22.1.
- 22.3. Using reported instances of project problems in the literature, list management difficulties and errors that occurred in these failed programming projects. (I suggest that you start with *The Mythical Man Month*, by Fred Brooks)
- 22.4. In addition to the risks shown in Figure 22.1, identify at least six other possible risks that could arise in software projects.
- 22.5. Fixed-price contracts, where the contractor bids a fixed price to complete a system development, may be used to move project risk from client to contractor. If anything goes wrong, the contractor has to pay. Suggest how the use of such contracts may increase the likelihood that product risks will arise.
- 22.6. Explain why keeping all members of a group informed about progress and technical decisions in a project can improve group cohesiveness.
- 22.7. What problems do you think might arise in extreme programming teams where many management decisions are devolved to the team members?
- 22.8. Write a case study in the style used here to illustrate the importance of communications in a project team. Assume that some team members work remotely and it is not possible to get the whole team together at short notice.
- 22.9. You are asked by your manager to deliver software to a schedule that you know can only be met by asking your project team to work unpaid overtime. All team members have young children. Discuss whether you should accept this demand from your manager or whether you should persuade your team to give their time to the organization rather than to their families. What factors might be significant in your decision?
- 22.10. As a programmer, you are offered promotion to a project management position but you feel that you can make a more effective contribution in a technical rather than a managerial role. Discuss whether you should accept the promotion.

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- Baker, F. T. (1972). 'Chief Programmer Team Management of Production Programming'. *IBM Systems J.*, 11 (1), 56–73.