Management Aspects of Requirements Engineering 8

In theory there is no difference between theory and practice. In practice there is.

Yogi Berra, baseball player, b. 1925

8.1 Introduction to Management

The management of the requirements engineering process is similar to the management of any other endeavour. Before starting out, it is necessary to understand what needs to be done. We need to know the sorts of activities that must be undertaken. We need to know whether there are any dependencies between the activities, *e.g.* whether one activity can commence only when another one has been completed. We need to know what kinds of skills are required to perform the activities.

It is good practice when preparing a plan to concentrate on the outputs that will be generated by each activity. Outputs can be seen and provide tangible evidence that work has been or is being done.

From all of this information, we can generate a plan in which we have identified the activities to be undertaken, the people who will perform the activities and the time it will take them to complete the activities. We can then start work following the plan and the manager can monitor work against the plan. In an ideal world, the plan will be followed to the letter. Nothing will go wrong and we shall arrive at the completion date of the plan with all the work done.

Reality can be very different. First, estimating the time and effort required to complete a task is very difficult unless the manager has extensive experience of tackling similar jobs in the past. Second, there may be difficulties discovered as work progresses that could not have been foreseen. For example, the plan may have relied on the availability of a key person at a specific time and, for any number of reasons, that person is not able to be there.

These events cause deviations from the plan and lead to the need to change it. Once a new plan has been put in place, the whole process is repeated. A frequent consequence of changing the plan is that, almost inevitably, the cost will increase and/or the time to completion will be later than previously estimated. An alternative approach is to keep the costs and completion time constant and reduce the amount of work to be done. This can be a viable strategy in some circumstances;
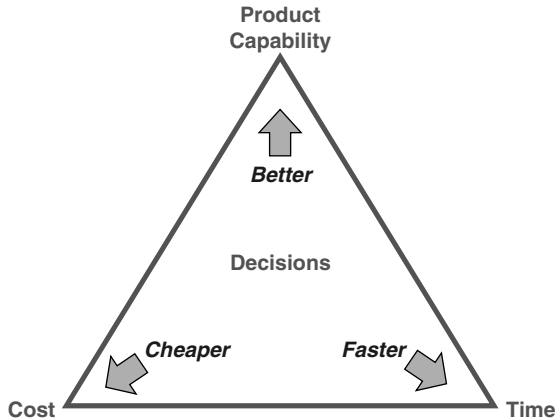
153

Figure 8.1 Capability, cost and time are interrelated.

for example, it may be imperative that a company has a new product out in the market place at a given time (to address the competition) and within a given budget (because that is all the company can afford), irrespective of how capable the product is (although at least a threshold level is usually necessary to avoid triviality). This situation is typical of the way in which commercial pressures can drive a project.

It is important to recognize that any project is constrained by three factors:

- product capability;
- cost;
- time-scale.

These three factors are related as indicated in Figure 8.1. Any change to one of these factors will have a consequential change to at least one of the others. Figure 8.1 also indicates that projects make progress by taking decisions. Every decision positions the project with respect to these three fundamental factors. It is the pipe dream of every project manager that each decision will improve the product capability while simultaneously reducing cost and shortening development time. In spite of its improbability, this dream is widely held.

8.2 Requirements Management Problems

This section introduces the specific problems that make the management of requirements more difficult than some other management activities. The first problem is that very few people have had significant experience of managing requirements. This is mainly because very few organizations have a defined requirements management process that is followed across the organization. As a result, people faced with a project that must address requirements, have very little experience to draw on. This makes estimation very difficult, because one of the main ingredients of the production of good estimates is extensive relevant

experience. Hence the starting point is not good and one is reminded of the joke in which one person asks another the way to a specific place and receives the reply "I wouldn't start from here"!

A corollary of this problem is more fundamental. If people have had little experience of requirements management, they may not even know what activities are necessary to develop requirements. Earlier chapters have addressed this issue and give direct guidance on the sorts of activities necessary to develop requirements of various types and in several contexts.

The second problem is that many people do not properly distinguish between user or stakeholder requirements and system requirements. Further, they often do not distinguish between system requirements and design specifications. In other words, they go straight for a solution rather than defining a solution-independent set of requirements. Again, this topic has been dealt with in preceding chapters.

The third main problem is that the way in which requirements are managed will depend upon the type of organization in which the work is being done. In preceding chapters we have discussed the different types of requirements and indicated how they are related. However, the way in which these processes are applied will depend upon the type of organization applying them. There are three main types of organization:

- Acquisition organizations that purchase systems and then use them to provide an operational capability. These organizations are mainly concerned with creating and managing stakeholder requirements, which subsequently are used as the basis for acceptance of the delivered system.
- Supplier organizations that respond to acquisition requests from acquisition organizations or higher level supplier organizations. These organizations receive input requirements and develop system requirements (and subsequently a design that is manufactured) in response to them. (Suppliers may also be acquirers of lower level subsystems or components, but this is a different form of acquisition because it is based on a design architecture.)
- Product companies that develop and sell products. These organizations collect stakeholder requirements but from their market place rather than from individuals or from operations organizations. The marketing department usually performs the collection of requirements. Product companies develop products in response to the stakeholder (marketing) requirements and sell the developed products. In a sense, these types of organizations encompass both acquisition and supply, but they tend to have a different relationship between the parts of the company that perform these roles compared with the standard acquisition and supplier relationship.

We will return to these types of organization later in this chapter.

The fourth problem that makes the management of requirements more difficult than some other management activities is that it is difficult to monitor progress when requirements are being generated. One difficult issue is to know whether the requirements set is complete – in order to decide whether the activity should stop. Even worse is the problem of determining how much progress has been made when the activity is nowhere near completion. This problem is further exacerbated by the need to assess the quality of the requirements generated.

A long list of requirements may have been generated, but how does the manager assess whether each requirement is well expressed? How can he or she tell whether each requirement is unique and whether they are all necessary?

The final problem is the perennial problem of changes. Requirements management should be the primary focus for change management. Any proposed change will usually relate to one or more requirements. The impact or knock-on effects of proposed changes are often difficult to assess, yet without this knowledge it is impossible to estimate the cost and time impact of introducing a change.

8.2.1 Summary of Requirement Management Problems

Specific management issues for requirements development arise in connection with:

- planning;
- monitoring progress;
- controlling changes.

The problems are subtly different depending on the organization involved. Therefore, in the rest of this chapter we consider each of these activities in the context of the three types of organizations introduced earlier. Finally, we draw together some common approaches in a concluding section.

8.3 Managing Requirements in an Acquisition Organization

8.3.1 Planning

The starting point for a project in an acquisition organization will be some form of concept description. In its most basic form this will be just an idea, but usually it will be more concrete and well founded. The reason for this is simple: projects must be authorized by the organization and the authorization process will require some documented evidence to support the case for spending time and money (resources). The evidence usually contains a brief description of what the users want to be able to do (the concept) and a supporting argument to indicate the benefits that will ensue to the operating organization from the provision of such a capability.

The information in the concept definition enables the project manager to begin planning. Since the concept definition contains a "*description of what the users want to be able to do*", we immediately have an initial set of stakeholders (*users*) for the system and an outline of one or more scenarios (*ability to do something*).

The first step in constructing a plan consists of identifying a fuller set of stakeholder types and a more complete set of scenarios that cover the complete range of expected operation of the system including, where useful, different modes of operation. Once the number of stakeholder types is known, it is possible to plan

in detail how to set about eliciting requirements. Actions that may be instantiated in the plan include:

1. Plan to interview one or more candidates of each stakeholder type. The requirements manager is responsible for ensuring that authorization to conduct the interviews is obtained from the candidates' managers. Authorization may depend on appropriate job codes and budgets being agreed (so that the candidates interviewed can book their time to the new project and consequently their managers are not penalized for their staff's absence while being interviewed). The requirements manager should also ensure that access to key operations staff is provided. Often the candidates' managers will be unwilling to release their most competent (useful and well informed) staff for an activity that is not in their short-term interests. It is up to the requirements manager to convince them of the value of doing so.

2. Allocate time to write up the interviews as interview reports and agree them with candidates interviewed.

3. Decide the interview strategy and communicate to the interviewers (who may be involved in the decision process anyway). The interview strategy will determine how each interview is conducted, for example, whether candidates should be prompted to express scenarios themselves, or be presented with a suggested scenario that they can criticize, etc.

4. Prior to the interviews it can be useful (but not necessarily easy) to get all the candidates together and explain the purpose of the interviews. If such a meeting can be arranged, it provides an excellent forum in which to discuss/develop user scenarios and to seek confirmation that all stakeholder types have been identified.

5. Agree and document the set of user scenarios that best reflect the purpose and operation of the system in its context. It is essential to ensure that the scenarios are not too blinkered in their scope.

6. Following the interviews, suggested stakeholder requirements can be extracted from the interview reports and agreed with the interview candidates.

7. Decide on a structure into which each of the stakeholder requirements can be entered.

8. Place each identified stakeholder requirement within the agreed structure and modify the structure as necessary.

9. Identify and record any constraints. Some constraints are product requirements such as physical size. Others are plan constraints such as budgeted cost and completion time. The product constraints should be entered into the stakeholder requirements specification. The planning constraints (such as budget, schedule, resource or quality) belong in the management plan and will have an influence on the planning activity.

10. Decide whether additional attributes are required to support the text of the requirements. Many organizations have standard sets of attributes that may be required or are merely advisory. Examples are priority, urgency, status, validation method and acceptance criterion.

11. Agree the criteria for the review of each individual requirement and for the requirement set as a whole. These criteria are best presented as a checklist for the reviewers. Ideally the review criteria should be created as early as possible
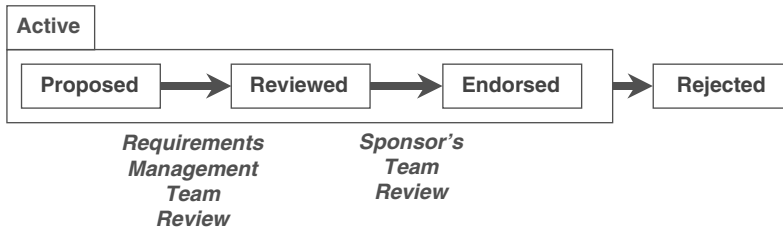
Figure 8.2 Example state transition diagram for stakeholder requirement status.

and distributed to the people writing the requirements. This enables them to appreciate what is required of them before they start to write.

12. Define the review process and relate this to the status of the individual requirements. This process can be summarized as a state transition diagram as shown in Figure 8.2. This shows that the initial state of a stakeholder requirement is "Proposed". When the requirements management team has reviewed it, it can move to the "Reviewed" status. Reviewed requirements can then be subjected to a further review by the sponsor's team and, when successful, will achieve "Endorsed" status. Note that, at any time, an "Active" requirement can be rejected. Review criteria must be determined for each review.

13. Perform reviews as required by the review procedure defined.

This list of activities implies the need for several decisions to be taken. This is the requirements manager's responsibility in collaboration with other interested parties such as the interview candidates, their managers and the overall sponsor for the system.

Care should be taken to assess any planning constraints to ensure that they are feasible and sensible. Stakeholders may demand that the system is put in service in a very short period of time and at low cost, but this may not be possible. A prime example of an unrealistic time constraint comes from the London Ambulance System developed to control ambulances in London in the early 1990s. The managers wanted to have the system in place so that they could supply the government with the performance statistics they were demanding. This very short development period and early in-service date were placed on the project as overall constraints, but were absolutely impossible to meet. Many contractors tried to persuade the ambulance service that it was impossible to meet these constraints and asked for the in-service date to be put back. These requests were refused and so many contractors did not bid. This left less experienced contractors to attempt to meet the impossible constraint. History shows that they completely failed to meet the demanded deadline and in the process caused serious harm to many people.

Realism in planning is essential for professional integrity.

8.3.2 Monitoring

Monitoring can start once the plan is in place. Obvious monitoring points are the completion of each activity in the plan. In the early stages the activities will

mainly revolve around preparing for the interviews, conducting them and reporting on them. These are easy to assess.

Three major milestones help to define the monitoring for the rest of the process:

- the definition of the structure for the requirements specification;
- the definition of the attributes required for each requirement;
- the definition of the review process(es) with associated checklists.

Once the structure is in place, it is possible to determine whether there are any areas where there should be requirements but none exist. These "holes" can be addressed by specific actions.

Once the attributes have been decided, progress in filling them can be monitored.

Finally, the progress against satisfying the review checklist criteria can be checked by measuring the number of requirements that have a specific status.

8.3.3 Changes

During the development of stakeholder requirements there will be a period of rapid and intense change. At this stage it is not sensible to have a formal change control process in place, because the situation is too dynamic and would just get in the way. However, at some point stability will begin to emerge and the requirements manager can determine when the requirements are sufficiently stable to subject further changes to a more formal process. Often this stage only occurs once all the requirements have been reviewed and reach the "Endorsed" state (see Figure 8.2).

Managing change is a vital activity in requirements development. The formality with which the process must be applied depends upon the development state of the project. Important stages include the following:

- stakeholder requirements used as the basis for a competitive bidding process;
- contract in place for the development of a system;
- design complete and manufacturing about to start;
- acceptance trials are being undertaken;
- the system is in service.

This list defines a set of points in a sequence of increasing commitment. Hence the further down this list a project is, the more formality is required in the change control process and the higher the likely cost impact of any change.

Whatever stage a project is at, the following steps are required in a change control process:

1. record the suggested change;
2. identify the impact of the suggested change;
3. decide whether to accept the change;
4. decide when to implement the change.

The suggested change should indicate the reason for the change and identify the stakeholder requirements that must be changed, added or deleted. The person or organization requesting the change must also be recorded.

At step 2 the impact will depend on the stage at which the change is suggested and this will require information about how the impacted requirements will influence the downstream information such as system requirements, design, manufacturing and in-service operations.

A Change Control Board will take step 3. The constitution of this board will depend on the organization, the scale of the system and the stage of development or operational use of the system. If a change is accepted, then step 4 is required. It may be that the change must be incorporated immediately irrespective of cost. Alternatively, the change may be deferred until a later release of the system. Any number of intermediate points may be appropriate and this clearly depends on circumstances.

It is always useful to have a set of states for a change and to represent this using a state transition diagram or statechart. Figure 8.3 contains an example.

It is also important to decide whether the status of requirements that are the subject of a change proposal should be changed to indicate this. There are at least two schools of thought on this point. One group takes the view that the dependency between the change and the requirements is held in the change proposal and hence it is not necessary to modify the requirement's status. Another group takes the view that when it has been decided that a change proposal will be incorporated, this means that the requirement is subject to change and this indicates that its review status has changed. (This is the view taken in Chapter 2.) Whatever position is adopted, it is necessary to decide on the status values for change proposals and whether these have any impact on the review status of the affected requirements.

In summary, acquisition organizations are mainly concerned with the creation of stakeholder requirements. This is a creative process that is difficult to bound initially. However, as the work progresses and the numbers of stakeholders and scenarios are agreed, it is possible to plan more accurately.
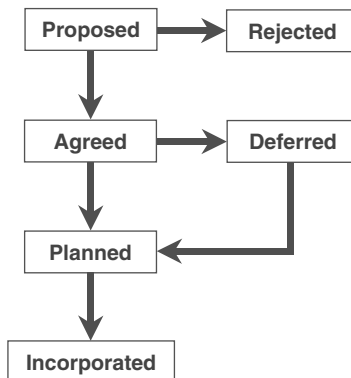
Figure 8.3 State transition diagram for change control.

Change control starts off with little formality, but this evolves as the project matures through development, manufacture and in-service operation.

8.4 Supplier Organizations

Supplier organizations respond to requests from customers to build systems or components for systems. Prior to obtaining a contract to build a system, they must prepare a proposal to indicate how they intend to go about the job and containing estimates of cost and time to complete the work. Often proposals are requested from a number of supplier organizations that compete to get the business. It is therefore useful to consider supplier organizations from two points of view: bidding for work and executing a contract once the work has been won.

8.4.1 Bid Management

This section looks at the management aspects of the process to create a proposal in response to a customer's set of requirements.

Planning

Often the starting point for requirements management within a supplier organization will be the receipt of an invitation to tender (ITT), also known as a request for proposal (RFP). Such an invitation or request will contain a set of requirements that must be satisfied by the system to be delivered.

The nature of the requirements received will depend upon the organization type of the customer (*i.e.* the organization that issued the invitation). If the customer is an acquisition organization it is likely that the requirements may be stakeholder requirements. Alternatively, the customer may be another supplier organization that is planning to subcontract one or more subsystems in a higher level system. In this case the requirements are likely to be system requirements with imposed design constraints. To make the narrative clearer we shall refer to the requirements received by a supplier as input requirements irrespective of what they really are.

Whatever the nature of the input requirements received, the first task is to assess them to determine whether they are:

- clearly identified and distinguished from purely descriptive information;
- unambiguous;
- consistent;
- free from undue design constraints.

In short, it is to determine whether they form a sound basis upon which to bid.

From a planning point of view, it is important to identify the number of requirements that must be satisfied. This provides a metric that can be used to get an idea of the scope of the work to be done.

During the review of the input requirements, any problems must be high-lighted by identifying specific problems and proposing a potential solution for them. Such solutions may involve suggesting alternative wording for the require-ments or even alternative requirements that can be satisfied – perhaps with off-the-shelf components.

Once the review has been undertaken, the problems it identifies must be addressed. This will usually involve entering a dialogue with the customer to obtain clarification or authorization for a proposed change. The extent of this dialogue will depend on the conditions attached to the invitation. If the invita-tion is to a single supplier, the dialogue can be entered into immediately.

However, if the invitation comes as part of a competitive bid it may be neces-sary to be more circumspect. The reason for this is that usually the competition rules insist that any queries from one potential supplier are copied (together with the customer's response) to all the other potential suppliers. Hence it is pos-sible that, by asking questions, one supplier can give information to the other competing suppliers. In this situation, it may be more appropriate to flag the problems and observations, but rather than going back to the customer with them, discuss them internally and decide how to handle them. Possible options for each problem include:

- ignore it;
- make an assumption and document it;
- decide that it is essential to ask the customer whatever the consequences.

The last action may lead to a further action to formulate the request to the customer in such a way that the competitors are helped least.

In parallel with sorting out the input requirements, work must proceed on cre-ating a proposed solution. Obviously, the primary output from this work is the pro-posal ready to be submitted to the customer. There are many different approaches to the creation of a proposal, but they all involve ensuring that each input require-ment is properly addressed. The bid manager must allocate each requirement to an individual or team who will be responsible for creating a response.

It is vital that all these responses be coherent, otherwise the proposal could end up proposing a random and disconnected set of bits and pieces. The best way of achieving this is to create a model that can form the basis for the solution. Depending on the nature of the proposal, this could be either an abstract model that can form the basis for building a set of system requirements, or it can be an outline design architecture. Each response to an input requirement can then be related to the model. This provides traceability from the input requirements and it provides the coherence so that inconsistencies can be identified. The problem is always that the people working on the solution must work with incomplete information based on documented assumptions and potentially best guesses at what the customer really meant. However, this is life!

At the end of the bid phase, when the proposal has been submitted, it is important that the bid team record all the information they have accumulated during the bid preparation. The bid team will often be under extreme pressure to finalize and submit the bid by the required submission date. Often, they will be ready to take a break and may forget to record properly all the information in a

form that can be used by the development team later. For large proposals, the amount of information can be significant and also the delay between submitting the proposal and starting development can be long (*e.g.* 6–8 months). In these circumstances, it is even more important that information is recorded, because the development team may not have any people who were involved in the bid preparation and, even if it does, after a significant period of time, they are likely to have forgotten some of the key assumptions and rationales.

A further important activity during the bid phase is the setting up of agreements with suppliers. These will usually be made conditional on the bid being successful, but they will have an impact on the level of detail to which the solution is developed. The basis of an agreement between a supplier organization and its suppliers must be founded on a set of requirements for the components to be supplied. The level of detail that is required during the bid phase will be set by agreement between the organizations involved. This will depend upon the nature of the working relationship that exists between the organizations and the degree of experience and trust that exists. (See the agreement process in the generic process introduced in Chapter 2.)

Monitoring

Measuring progress during the creation of a proposal is vital, because time-scales are usually constrained and the submission date is not negotiable. The end-point must be that the proposal clearly indicates how each input requirement will be met. However, merely asserting how a requirement will be met is not sufficient. It is also necessary to check that all the assertions are valid. This is an aspect of the review process, but an indication of progress can be obtained by comparing the percentage of input requirements that have been traced to the solution model (and hence to either system requirements or design components).

A measure of the amount of outstanding work to be done can be obtained by assessing the number of input requirements that still have outstanding problems logged against them together with the number of input requirements that still have no proposed solution.

Another important milestone in the development of a solution is the creation of a model with which the team are content. Ensuring that such a model is produced quickly and that there is "buy in" is a crucial task for the manager.

In addition to all of these monitoring devices, a measure of the quality of the system requirements must also be made. This can be done in a similar manner to that described above for acquisition organizations monitoring the creation of stakeholder requirements, by defining states and linking the progression through those states to review criteria.

Changes

During the preparation of a proposal there are three potential sources of change:

- customer;
- suppliers,
- internal.

One might think that there would be no customer changes during the preparation of a proposal, and ideally this would be true. However, it is safest not to assume this. Typically the probability of change is roughly proportional to the size of the system (or component) to be developed. For very large systems, suppliers often commence their bidding activities with an early draft of an RFP in order to get the bid team running and thinking along the right lines. Later versions are issued at intervals and may contain significant changes.

The first task on receipt of a new version of the RFP (or its requirements) is to determine the nature and extent of the changes. Depending on the customer and the medium used to issue the RFP, the location of the changes may be highlighted or completely unknown. Once found, the changes must be related to the work already done and an assessment made of the new work and rework that is now necessary.

Changes from customers can also come via responses to queries from bidders. These are usually well focused and can be assessed quite readily.

Changes instigated by suppliers are more likely. These may be in response to an initial request for a proposal to indicate that they cannot meet the requirements as defined, or the changes may come later in the process when the supplier discovers that what was originally thought to be possible turns out not to be.

Internal changes arise for much the same reasons as the suppliers' changes. Initial assumptions turn out to be invalid and therefore an alternative approach must be taken.

Whatever the source of the change, it is essential that the various requirements baselines are kept up-to-date, *i.e.*:

- input requirements;
- requirements placed on suppliers;
- assumptions and interpretations made within the bid team.

8.4.2 Development

Planning

The development stage of a project commences with an agreed contract based on the proposal submitted to the customer and modified during contract negotiations. In addition, there will be other information generated during the bidding process, but not necessarily incorporated into the proposal. This may include detailed requirements, assumptions, outline or detailed design information and an initial assessment of the risks involved in undertaking the development. This information will have been used to arrive at the estimated time and cost of the work.

The activities involved in the development stage have to be more considered and in much more detail than those at the proposal preparation or bidding stage. One important difference is that instead of producing a proposal, the proposal previously submitted may now be part of the input requirements.

The information generated during development activities will depend on the nature of the development but will inevitably include the creation of a solution model. This may be done in two stages, the first producing an abstract model and the second producing one or more potential design solutions. If more than one solution is created, then it will be necessary to define the criteria for making

a comparative assessment of the solutions and then deciding which one to take forward. This comparative assessment leads to the creation of options and the possibility of trading off some requirements against others. This tradeoff may be done entirely internal to the supplier organization or it may involve the customer and/or the suppliers.

Activities are necessary to ensure that all the input requirements in the contractual specification are addressed and that the proposed solution embodied in the system requirements and design is adequate. The level of detail will usually have to be improved to ensure that, at the most detailed level, nothing is left to chance.

During the development stage, it is important to ensure that the means of testing (or otherwise demonstrating the satisfaction of) each requirement is understood and documented.

The first step is to undertake an audit of the available information to determine its extent and quality. Ideally all the information created by the bid team should have been collected together and archived ready for use in the development process. All too frequently this is not the case and significant information can be lost. This can cause a major discontinuity between the intentions of the bid team and what is actually done by the development team. This, in turn, can put the organization's business at risk.

Following the audit the project manager must determine, by comparing the proposal submitted with the contract, what has changed since the proposal was submitted. The next step is to determine what the impact of these changes will be and to plan activities to make any consequential changes to the system requirements, design and component specifications.

Any outstanding assumptions and comments must be referred back to the customer, although ideally these will have been addressed during the negotiation of the contract.

A further issue that often arises when planning a development is whether the system will be delivered with full functionality at once, or whether there will be a series of releases with increasing functionality culminating with the final complete release. Supplying a series of releases provides the customer with an initial capability early. This approach is very popular in software development where there may be some doubts about the usability of the system.

From a requirements management point of view, releases must be planned on the basis of the set of requirements that will be implemented in each release. These decisions can be recorded by adding a release attribute to each requirement. Such attributes can either be enumerated lists or Boolean. A set of possible values for an enumeration list would be:

$$\{\text{TBD, Release 1, Release 2, Release 3}\}$$

where TBD stands for "to be decided" and will usually be the default value.

When using Boolean attributes each has the value true or false and one is created for each release.

Monitoring

Monitoring progress during the development should be focused on assessing the current extent and quality of the output information to be generated. It is also

vital to know how much time and effort have been consumed. From this knowledge it is possible to estimate whether the outputs will be complete within the effort and time allowed in the plan. This estimate must take into account the manager's knowledge of when or at what rate the information outputs are expected to be achieved.

If the manager discovers that progress is lagging behind the plan, then appropriate corrective actions can be taken. These will inevitably lead to a change in the plan, such as adjusting the duration or resources of existing activities, or adding extra activities.

The monitoring activities must ensure that project information is up-to-date. It is especially important that input requirements and supplier requirements are modified in line with agreed changes and that traceability links exist from input requirements through to supplier requirements via the proposed solution.

Changes

The same three sources of changes arise in the development as already identified in the bidding stage. The extent of customer changes is likely to be far less during development than during bidding. Internal and supplier changes are just as likely. The procedure for identifying the nature and consequence of any change is just the same. However, the consequence of a change at this point is far more serious. Small changes can be accommodated within the customer contract or supplier agreement. However, more serious changes may require a change to the terms and conditions of either. Changes introduced during development will usually have an impact on both the time-scale (schedule) of the development and the cost. Once the consequences have been determined, it is then a commercial decision whether to absorb any cost and time penalties or whether to negotiate with the customer and/or suppliers.

When a change is proposed for a development with several releases, it is a function of change management to decide which release the change will be implemented in.

In summary, supplier organizations respond to customer requests by preparing a proposal and if successful they go on to develop a system. Making sure that the requirements issued by the customer are a sound basis for the development is of prime importance. Keeping the input requirements up-to-date as changes are introduced ensures that the project is soundly based. Traceability from the input requirements to the proposed solution, to their suppliers' requirements and to testing information ensures that the impact of change can be assessed and that the organization at all times knows the status of the development.

8.5 Product Organizations

Product organizations define stakeholder requirements and develop a product to satisfy them. Hence they have many of the characteristics of acquisition and supplier organization. The main difference is that the customer–supplier agreement at the top level of the supply chain is within the overall organization,

although different departments usually undertake the roles of defining stake-holder requirements and developing products to satisfy them.

8.5.1 Planning

Single Product Version

Planning for a single version of a single product involves the same activities as for the acquisition and the supplier organizations. The difference between the bidding and the development stages may still be there. For example, when start-ing a new product, the company may want to have an initial idea of what is involved in building it. To achieve this it is necessary to elicit the stakeholder requirements and to produce an outline solution.

Producing the stakeholder requirements is very similar to the way in which acquisition organizations do it. There is a need to identify stakeholders and user scenarios. However, rather than interviewing real stakeholders, what usually happens is that people volunteer (or are volunteered) to act as "surrogate" stake-holders. This means that they adopt the role of a defined stakeholder and define, from that point of view, what the stakeholder requirements are. From a planning point of view there is little difference. People must still be identified and inter-viewed. Requirements must be extracted, properly formulated and embodied in an agreed structure. Finally, the requirements must be reviewed and their quality established.

Producing an outline solution is very similar to the work done when creating a proposal. The main difference is that there is direct access to the people who are formulating the requirements and hence there is the possibility of a much more interactive development where the stakeholder requirements can be modified to make implementation easier, to reduce time to market and to reduce cost. It is even possible that the capability of a proposed product can be enhanced within the given budget by feeding back technical possibilities to the owners of the stakeholder requirements. It is clearly much easier to gain clarification where requirements are vague or confusing etc. This may sound very informal and, in some cases, it can be. However, the degree of formality must be agreed prior to starting the work.

When an agreed set of stakeholder requirements and an outline solution have been produced and reviewed by the product organization, it may decide not to proceed with the development or it may decide to invest further funds and go to a more detailed design or even to produce an early prototype. Thus it can be seen that a product can proceed by means of a set of stages where each stage builds upon previous work. Each stage has a given budget and a set of objectives. At the end of each stage there is a review at which progress against the budget and the objectives is assessed. This procedure can be described using the stage gate concept as indicated in Figure 8.4.

At the initial gate (Stage Gate 0), a set of objectives, budget and time-scale are defined. These feed into a planning process which determines the information which must be generated in order to achieve the stage's objectives and a work plan which will achieve the required state within the budget. The initial objective may be merely an exploration of the concept and some preliminary estimation
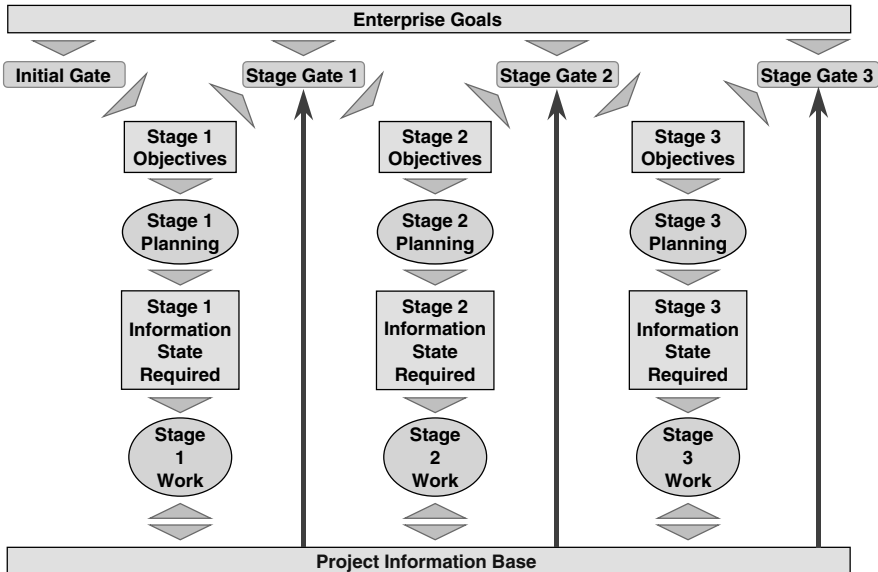
Figure 8.4 Stage gates and project work.

of market size, etc. At the end of the stage the work done is reviewed against the objectives to determine whether the project should continue or whether it should stop. This review should also take into account the current business objectives, which may have changed or evolved during the stage.

If the project is allowed to continue then a further budget, time-scale and objectives will be agreed. For the second stage it may be decided to go for a costed proposal as discussed above and a more detailed exploration of market conditions. The stage gate review will then check whether the estimated cost is in line with the expected revenue that can be earned. This leads naturally into a decision to cancel or commit further funds. If the latter, then a decision has to be taken about how far the development should be taken, for example:

- do more investigation into the development and production costs;
- develop a prototype;
- produce a small batch and try them out with real customers;
- go into full production;
- and so on.

Hence the stage gate process can continue one stage at a time with gradual commitment of funds and resources. This enables the organization to control its investment strategy and keep an eye on its likely return on investment.

Multiple Products and Versions

Product organizations may have several versions of the same product at different stages in their evolution. Typically they will have some product versions in use by
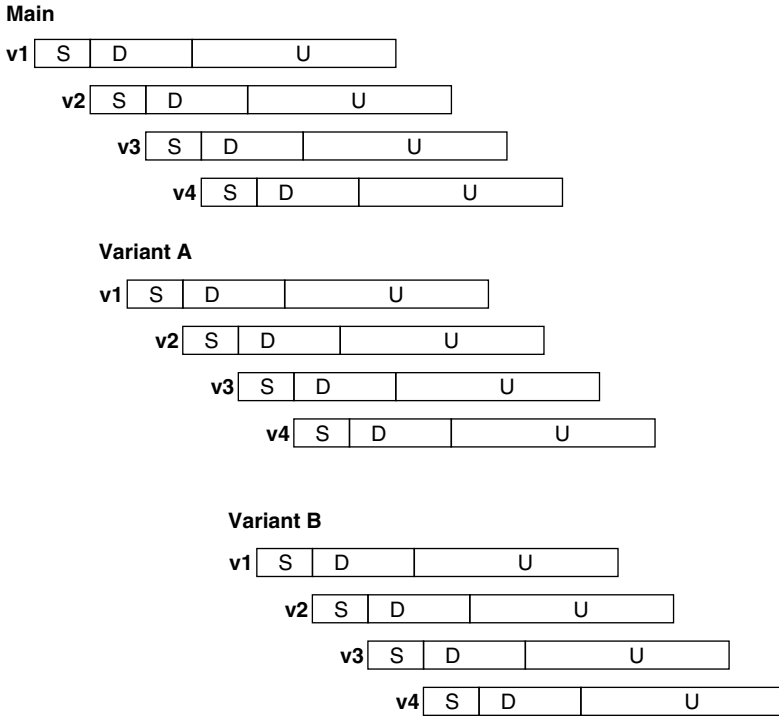
Main

v1 | S | D | U
v2 | S | D | U
v3 | S | D | U
v4 | S | D | U

Variant A

v1 | S | D | U
v2 | S | D | U
v3 | S | D | U
v4 | S | D | U

Variant B

v1 | S | D | U
v2 | S | D | U
v3 | S | D | U
v4 | S | D | U

Figure 8.5 Versions and variants.

people who have purchased them, some in development and some being defined. From a planning point of view, each version can be treated as a separate "project" going through its own set of stages and gates. However, there is an additional need to plan for the different versions of the products in the pipeline. It is important to plan when each version in current use will be phased out and replaced by a later model. These aspects can also be brought under the stage gate process, so that a set of stage gate reviews can be held at the same time to determine the best investment strategy to keep or increase market share.

A further factor in this area is that there may well be different versions for different markets. For example, it may be necessary to have user interfaces that support different natural languages for sale in different countries.

To cope with this type of difference we introduce the notion of a "variant" meaning "differing in form or details from the main one". Thus we can have the "main one" (perhaps better expressed as the "core product") being a product with the user interface in English and variants for the French, German and Spanish markets. Each variant can have its own versions such that each version is an improvement over the previous one.

Figure 8.5 indicates how there can be parallel versions and variants of a single product each at a different stage of its evolution. The letters S, D and U indicate whether a product is being specified, being developed or being used. Each of these states corresponds to one or more stages in the stage gate lifecycle.

From a requirements management point of view, each variant will have many requirements in common with the core product, but it will have some requirements that are specific to that variant and therefore differentiate it from other variants. On the other hand, there may be no different requirements for each version of a variant, because each version is an attempt to satisfy the same set of requirements (hopefully improving as the sequence goes on).

In the previous section we used the term "release" and readers may be confused between a release and a version. The difference is that a release is a version that is delivered to the customer, whereas not all versions will be.

Planning the evolution of the variants and their versions for each product is a further organizational task that can also be controlled using the stage gate mechanism. The development for these may overlap in time and there will be a need to support at least one version of each variant while it is in operational use.

The activities involved in doing the specification and development are very similar to those introduced earlier for the acquisition and supplier organizations. The major difference is that, where different versions and variants of the same product exist, there is common information being used in several contexts. This complicates the management of the requirements and makes it essential to understand how the requirements baselines for each version and variant overlap. This overlap is especially important where there are common requirements covering several versions and variants and leads to extra complications in the management of change (see below).

8.5.2 Monitoring

Monitoring progress in a product organization uses exactly the same mechanisms as for the other organizations. When stage gates are used as the basis for organizational decisions, the process of planning will involve the identification of the data state that must exist at the end of the stage. Progress can then be measured based on the extent to which the desired state has been reached. As a general rule such states can be measured in the following terms:

- whether new objects exist that will become targets for traceability links (*e.g.* solution objects in response to stakeholder requirements, or design objects in response to system requirements);
- whether attribute values exist;
- whether the required review status exists;
- whether traceability links exist from one data set to others (*e.g.* from stakeholder requirements to system requirements, from system requirements to design and from all of these to testing strategies and possibly test results).

Measures expressed as a percentage of required data quality currently achieved provide useful metrics for both quality of data and progress within a stage.

8.5.3 Changes

As mentioned earlier, the major additional factor for change management in a product organization is where several variants of a product have common
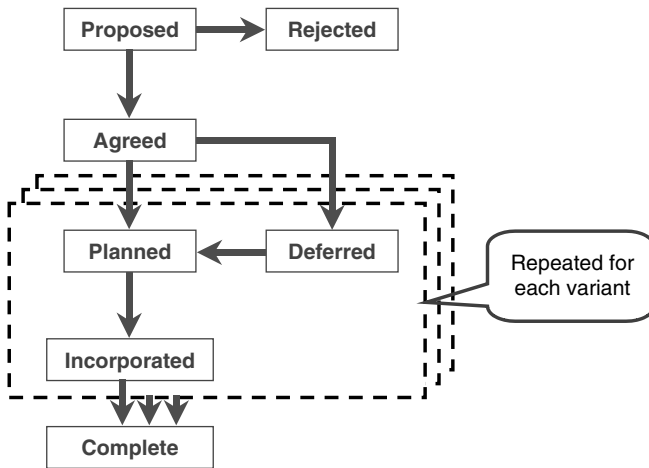
Figure 8.6 Modified STD for change management with variants.

requirements and a change proposal is raised against one or more of them. The questions that must be answered are:

• will all the variants want to incorporate the change?;
• when will they want to incorporate it?

Often the answer will be that all variants will want to incorporate the change, but not at the same time! This introduces an extra state into the change handling state transition diagram (see Figure 8.6) because each variant must incorporate the change before the change can be completed.

Figure 8.6 also indicates that it is necessary that there are planned, deferred and incorporated states for each variant. The change can only achieve the status of complete when all the variants have reached their individual "incorporated" state.

In summary, product organizations perform similar tasks to both acquisition and supplier organizations. In addition, they must take care to control their product portfolio so that an appropriate degree of commitment is made and the overall commercial exposure is acceptable.

8.6 Summary

The summary is grouped under the headings of planning, monitoring and changes in line with the presentation of the main body of the text.

8.6.1 Planning

Planning should be driven by the outputs that must be created. Activities to create the required outputs can then be introduced. Outputs can be categorized as follows:

• types of information objects (*e.g.* stakeholders, stakeholder requirements, system requirements, design or solution objects);

- attributes associated with an information object;
- links between information objects to establish traceability, testing strategy, etc.;
- review criteria to determine the required quality of information and associated attributes;
- achievement of a particular state possibly via progression through a series of states (*e.g.* by reviews).

Before any work can be started, the work must be authorized by the organization in which it will be undertaken. A mechanism such as stage gates is appropriate for acquisition and product organizations to control the level of commitment and consequent financial and/or commercial exposure they are willing to tolerate. In supplier organizations there must be an authorization to prepare a proposal and this is usually accompanied by an allowed budget. Permission to progress to development will usually be embodied in the signing of a contract with the customer.

Evolutionary development should be considered to be the norm, especially for unprecedented systems. This leads naturally into the concepts of releases, versions and variants.

8.6.2 Monitoring

It is vital that progress is measured by investigating the current state of the required outputs. Progress measured in this way together with the amount of effort and time used compared with the plan enables the viability of the plan to be established. Ignoring the outputs and just measuring time and effort consumed gives a distorted view that is not realistic.

8.6.3 Changes

The most critical aspect of a change is the impact that it will have on the system to be developed and hence on the development plan. Understanding the impact can only be achieved provided that the current states of the (project) outputs are available and up-to-date. Of particular importance here are the links that exist to provide traceability from input information to derived information.

Deciding when a change can or should be incorporated will usually impact the plan and may cause serious re-planning – depending on the scope of the change. Changes can also lead to the introduction of additional releases, version or variants.