UNIT 7 PROJECT MONITORING AND CONTROL

Objectives

The objectives of this unit are:

- to provide an understanding of how the monitoring system is designed,
- to explain concept of control and its various types,
- to focus on types of control Processes,
- to throw light on designing of control system.

Structure

7.1 INTRODUCTION

Monitoring is collecting, recording, and reporting information concerning any and all aspects of project performance that the project manager or others in the organization wish to know. In our discussion it is important to remember that monitoring, as an activity, should be kept quite distinct from controlling (which uses the data supplied by monitoring to bring actual performance into approximate congruence with planned performance), as well as from evaluation (through which judgements are made about the quality and effectiveness of project performance).

7.2 DESIGNING OF THE MONITORING SYSTEM

The first step in setting up any monitoring system is to identify the key factors to be controlled. Clearly, the project manager wants to monitor performance, cost, and time but must define precisely which specific characteristics of performance, cost, and times should be controlled and then establish exact boundaries within which control should be maintained. And there may also be other factors of importance worth noting, at least at certain points in the life of the project. for example, the number of labour hours used, the number or

extent of engineering changes, the level of customer satisfaction, and similar items may be worthy of note on individual projects.

But the best source of items to be monitored is the project Action Plan - actually, the set of Action Plans that describe what is being done, when, and the planned level of resource usage for each task, work package, and work unit in the project. The monitoring system is a direct connection between planning and control. If it does not collect and report information on some significant element of the plan, control can be faulty or missing. The measured and reported to the control system, but it is not sufficient. For example, the project manager might want to know about changes in the client's attitudes toward the project. Information on the morale of the project team might be useful in preparing for organizational or personnel changes on the project. These two latter items may be quite important, but are not reflected in the project's action plan.

Unfortunately, it is common to focus monitoring activities on data that are easily gathered - rather than important - or to concentrate on "objective" measures that are easily defended at the expense of softer, more subjective data that may be more valuable for control. Above all, monitoring should concentrate primarily on measuring various facets of output rather than activity. It is crucial to remember that effective project managers are not primarily interested in how hard their project teams work. They are interested in results.

Given all this, performance criteria, standards, and data collection procedures must be established for each of the factors to be measured. The criteria and data collection procedures are usually set up for the life of the project. The standards themselves, however, may not be constant over the project's life. They may change as a result of altered capabilities within the parent organization or a technological breakthrough made by the project team; but, perhaps more often than not, standards and criteria change because of factors that are not under the control of the project manager.

Next, the information to be collected must be identified. This may consist of accounting data, operating data, engineering test data, customer reactions, specification changes, and the like. The fundamental problem in this regard is to determine precisely which of all the available data should be collected. It is worth repeating that the typical determinant for collecting data too often seems to be simply the ease with which it can be gathered. Of course, the nature of the required data is dictated by the project plan, as well as by the goals of the parent organization, and by the fact that it is desirable to improve the process of managing projects.

Therefore, the first task is to examine the project plans in order to extract performance, time, and cost goals. These goals should relate to some fashion to each of the different levels of detail; that is, some should relate to the project, some to its tasks, some to the work packages, and so on. Data must be identified that measure achievement against the goals, and mechanisms designed for gathering and storing such data. Similarly, the process of developing and managing projects should be considered and steps taken to ensure that information relevant to the diagnosis and treatment of the project's organizational infirmities and procedural problems are gathered.

7.3 HOW TO COLLECT DATA

Given that we know what type of data we want to collect, the next question is how to collect this information. At this point in the construction of a monitoring system, it is necessary to define precisely what pieces of information should be gathered and when. In most cases, the project manager has options. questions

then arise. Should cost data be gathered before or after some specific event? Is it always mandatory to collect time and cost information at exactly the same point in the process? What do we do if a specific piece of desirable data is difficult to collect because the data source (human) fears reporting any information that might contribute to a negative performance evaluation? What do we do about the fact that some use of time is reported as "hours charged" to our project, and we are quite aware that our project has been charged for work done on another project that is over budget? Are special forms needed for data collection? Should we set up quality control procedures to ensure the integrity of data transference from its source to the project information system? Such questions merely indicate the broad range of knotty issues that must be handled.

A large proportion of the data collected may take one of the following forms, each of which is suitable for some types of measures.

1. **Frequency Counts :** A simple tally of the occurrence of an event. This type of measure is often used for "complaints," "number of times a project report is late," "bugs in a computer program" and similar items. The data are usually easy to collect and are often reported as events per unit time or events as a percent of a standard number.
2. **Raw Numbers :** Dates, hours, physical amounts of resources used, and specifications are usually reported in this way. These numbers are reported in a wide variety of ways, but often as direct comparisons with an expected or standard number. Also, "variances" are commonly reported as the ratios of actual to standard. Comparisons on ratios can also be plotted as a time series to show changes in system performance.
3. **Subjective Numeric Ratings :** These number are subjective estimates, usually of a quality, made by knowledgeable individuals or groups. They can be reported in most of the same ways that objective raw numbers are, but care should be taken to make sure that the numbers are not manipulated in ways only suitable for quantitative measures. Ordinal rankings of performance are included in this category.
4. **Indicators:** When the project manager cannot measure some aspect of system performance directly, it may be possible to find an indirect measure on indicator. The speed with which change orders are processed and changes are incorporated into the project is often a good measure of team efficiency. Response to change may also be an indicator of the quality of communications on the project team. When using indicators to measure performance, the project manager make sure that the linkage between the indicator and the desired performance measure is as direct as possible.
5. **Verbal Measures :** Measures for such performance characteristics as "quality of team member cooperation," "morale of team members," or "quality of interaction with the client" frequently take the form of verbal characterization. As long as the set of characterizations is limited, and the meanings of the individual terms are consistently understood by all, these data serve their purposes reasonably well.

After data collection has been completed, reports on project progress should be generated. These include project status reports, time/cost reports, and variance reports, among others. Causes and effects should be identified and trends noted. Plans, charts, and tables should be updated on a timely basis. Where known, "comparables" should be reported, as should statistical distributions of previous data if available. Both help the project manager (and others) to interpret the data being monitored.

The purpose of the monitoring system is to gather and report data. The purpose of the control system is to act on the data. To aid the project controller, it is

helpful for the monitor to carry out some data analysis. Significant variances from plan should be highlighted or "flagged" so that they cannot be overlooked by the controller. The methods of statistical quality control are very useful for determining what size variances are "significant" and sometimes even help in determining the probable cause(s) of variances. Where causation is known, it should be noted. Where it is not known, an investigation may be in order. The decisions about when an investigation should be conducted, by whom, and by what methods are the prerogative of the project controller, although the actual investigation may be conducted by the group responsible for monitoring.

In creating the monitoring system, some care should be devoted to the issues of honesty and bias. The former is dealt with by setting in place an internal audit. The audit serves the purpose of ensuring that the information gathered is honest. No audit, however, can prevent bias. All data are biased by those who report them, advertently or inadvertently. The controller must understand this fact of life. The first issue is to determine whether or not the possibility of bias in the data matters significantly. If not, nothing need be done. Biased findings and correcting activities are worthwhile only if data with less or no bias are required.

There is some tendency for project monitoring systems to include an analysis directed at the assignment of blame. This practice has doubtful value. While the managerial dictum "rewards and punishments should be closely associated with performance" has the ring of good common sense, it is actually not good advice. Instead of motivating people to better performance, the practice is more apt to result in lower expectations. If achievement of goals is directly measured and directly rewarded, a tremendous pressure will be put on people to understate goals and to generate plans that can be met or exceeded with minimal risk and effort.

7.4 INFORMATION NEEDS AND THE REPORTING PROCESS

Everyone concerned with the project should be tied into the project reporting system. The monitoring system ought to be so constructed that it addresses every level of management, but reports need not be of the same depth or at the same frequency for each level. Lower-level personnel have a need for detailed information about individual tasks and the factors affecting such tasks. Report frequency is usually high. For the senior management levels, overview reports describe progress in more aggregate terms with less individual task detail. Reports are issued less often. At times it may be necessary to move information among organizations, as illustrated in Figure 7.1, as well as among managerial levels.

Reports must contain data relevant to the control of specific tasks that are being carried out according to a specific schedule. The frequency of reporting should be great enough to allow control to be exerted during or before the period in which the task is scheduled for completion.

In addition to the criterion that reports should be available in time to be used for project control, the timing of reports should generally correspond to the timing of project milestones. This means that project reports may not be issued periodically-excepting progress reports for senior management. There seems to be no logical reason, except for tradition, to issue weekly, monthly, quarterly, etc., reports. Few projects require attention so neatly consistent with the calendar. This must not be taken as advice to issue reports "every once in a while." Reports should be scheduled in the project plan. They should be issued on time. The report schedule, however, need not call for periodic reports.

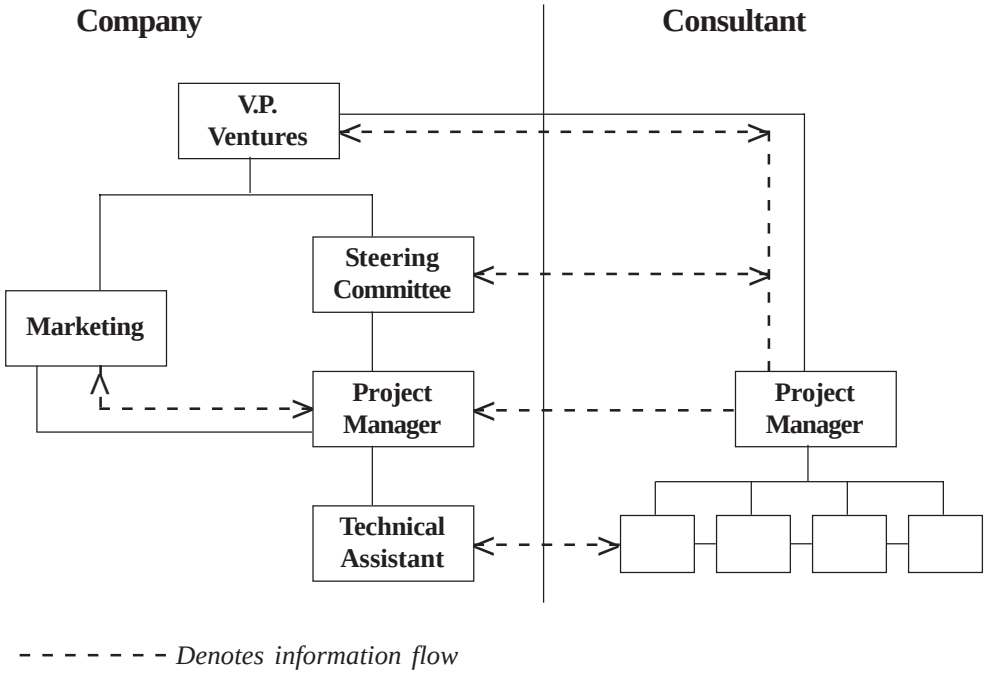

Figure 7.1: Reporting and information flows between organisations working on a common project

Identification of project milestones depends on who is interested. For senior management, there are only a few milestones even in large projects. For the project manager, there may be many critical points in the project schedule at which major decisions must be made, large changes in the resource base must be initiated, or key technical results achieved. The milestones relevant to lower levels relate to finer detail and occur with higher frequency.

The nature of the monitoring reports should be consistent with the logic of the planning, budgeting, and scheduling systems. The primary purpose is, of course, to ensue achievement of the project plan through control. There is, therefore, little reason to burden operating members of the project team with extensive reports on matters that are not subject to control - at least not by them. The scheduling and resource usage columns of the project Action Plan will serve as the key to the design of project reports.

There are many benefits of detailed reports delivered to the proper people on a timely basis. Among them are :

- Mutual understanding of the goals of the project.
- Awareness of the progress of parallel activities and of the problems associated with coordination among activities.
- More realistic planning for the needs of all groups and individuals working on the project.
- Understanding the relationships of individual tasks to one another and to the overall project.
- Early warning signals of potential problems and delays in the project.
- Minimizing the confusion associated with change by reducing delays in communicating the change.
- Faster management action in response to unacceptable or inappropriate work.
- Higher visibility to top management, including attention directed to the immediate needs of the project.
- Keeping the client and other interested outside parties up to date on project status, particularly regarding project milestones and deliverables.

7.5 REPORT TYPES

For the purposes of project management, we can consider three distinct types of reports: routine, exception, and special analysis. The routine reports are those issued on a regular basis; but, as we noted above, regular does not necessarily refer to the calendar. For senior management, the reports will usually be periodic, but for the project manager and lower-level project personnel, milestones may be used to trigger routine reports.

At times, it may be useful to issue routine reports on resource usage periodically, occasionally on a weekly or even daily basis.

Exception reports are useful in two cases. First, they are directly oriented to project management decision making and should be distributed to the team members who will have prime responsibility for decisions or who have a clear "need to know." Second, they may be issued when a decision is made on an exception basis and it is desirable to inform other managers as well as to document the decision - in other words, as part of a sensible procedure for protecting oneself.

Special analysis reports are used to disseminate the results of special studies conducted as part of the project or as a response to special problems that arise during the project. Usually they cover matters that may be of interest to other project manager, or make use of analytic methods that might be helpful on other projects. Studies on the use of substitute materials, evaluation of alternative manufacturing processes, availability of external consultants, capabilities of new software, and descriptions of new governmental regulations are all typical of the kind of subjects covered in special analysis reports. Distribution of these reports is usually made to anyone who might be interested.

The real message carried by project reports is in the comparison of activity to plan and of actual output to desired output. Variances are reported by the monitoring system, and responsibility for action rests with the controller. Because the project plan is described in terms of performance, time, and cost, variances are reported for those same variables. Project variance reports usually follow the same format used by the accounting department, but at times they may be presented differently.

This variance report shows the ratio of the material estimated to the material used in projects. As a result of this information, the program manager decides that it would be less expensive for the company to carry small inventories in a few of the commonly used high alloys, and to estimate (and price) material use closer to actual expectations.

The Earned Value Chart

Thus far, we have covered monitoring for parts of projects. The monitoring of performance for the entire project is also crucial because performance is the raison d'etre of the project. *Individual* task performanxce must be monitored carefully because the timing and coordination between individual tasks is important. But overall project performance is the crux of the matter and must not be overlooked. One way of measuring overall performance is by using an aggregate performance measure called earned value.

A serious difficulty in comparing actual expenditures against budgeted or baseline expenditures for any given time period is that the comparison fails to take into account the amount of work accomplished relative to the cost incurred. The earned value of work performed for those tasks in progress is found by multiplying the estimated percent completion for each task by the

planned cost for that task. The result is the amount that "should" have been spent on the task thus far. This can then be compared with the actual amount spent. A graph such as that shown in Figure 7.2 can be constructed and provides a basis for evaluating cost and performance to date. If the planned (baseline) total value of the work accomplished is in balance with the planned cost (i.e., minimal scheduling variance), then top management has no particular need for a detailed analysis of individual tasks. Thus the concept of earned value combines cost reporting and aggregate performance reporting into one comprehensive chart.

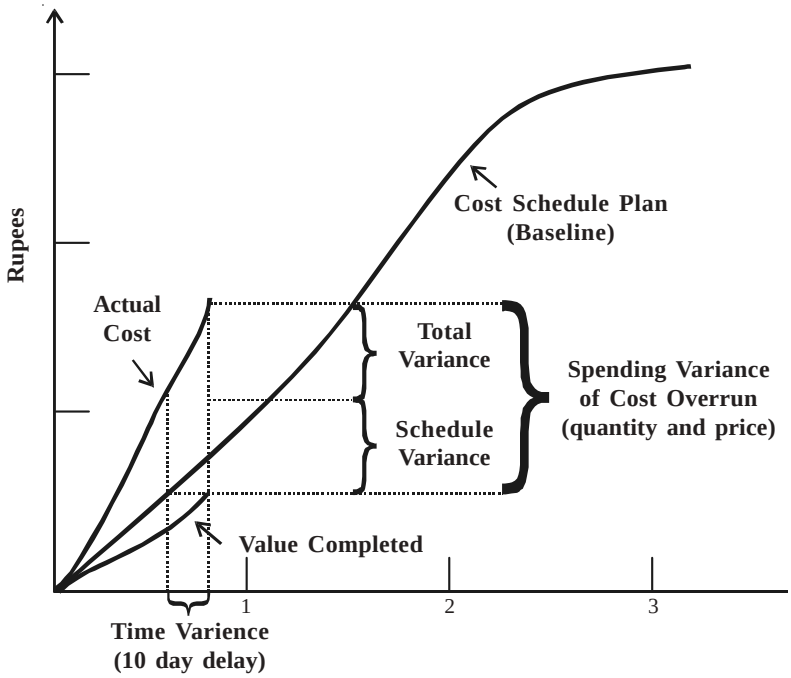

Figure 7.2: Earned value Chart

Three variances can be identified on the earned value chart. The spending variance is the actual cost less the value completed, the schedule variance is the value completed less the baseline plan, and the total variance is the sum of the two: actual less planned cost. Top management, as mentioned above, is usually most concerned with the schedule (or time) variance, whereas the project controller is probably concerned with the spending variance (cost overrun) and the controller of the parent will track the total variance. The project manager is concerned with all the three, of course.

If the earned value chart shows a cost overrun or performance under-run, the project manager must figure out what to do to get the system back on target. Options include such things as borrowing resources for activities performing better than expected, or holding a meeting of project team members to see if anyone can suggest solutions to the problems, or perhaps, notifying the client that the project may be late or over budget.

Activity 1

Managing Director of a Pharmaceutical of Company has approached you to design the monitoring system for his organization.

a) List out the steps that you would take to design the monitoring system for the organization.

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b) How would you collect the required data for monitoring purposes?

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c) What information would you provide in your Report to the Managing Director?

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7.6 PROJECT CONTROL

Nature of Control

Control is the act of comparing the planned performance with the actual and reducing the difference between the two. It is also the last element in the implementation cycle of planning-monitoring-controlling. Information is collected about system performance, compared with the desired (or planned) level, and action taken if actual and desired performance differ sufficiently that the controller (manager) wishes to decrease the difference. Note that reporting performance, comparing the differences between desired and actual performance levels, and accounting for why such differences exist are all parts of the control process.

Objectives of control are :

1. The regulation of results through the alteration of activities.
2. The stewardship of organizational assets.

Most discussions of the control function are firmly focused on regulation. The project manager needs to be equally attentive to both regulation and conservation. The Project Manager is shepherd of the organization's resources. The project manager must guard the physical assets of the organization, its human resources, and its financial resources. The processes for conserving these three different kinds of assets are different.

Types of Control

Physical Asset Control

Physical asset control requires of the use of these assets. It is concerned with the asset maintenance, whether preventive or corrective. At issue also is the timing of maintenance or replacement as well as the quality of maintenance.

If the project uses considerable amount of physical equipment, the project manager also has the problem of setting up maintenance schedules in such a way as to minimize interference with the ongoing work of the project. It is critical to accomplish preventive maintenance prior to the start of that final section of the project life cycle known as the Last Minute Panic (LMP).

Physical inventory, whether equipment or material, must also be controlled. It must be received, inspected (or certified), and possibly stored prior to use. Records of all incoming shipments must be carefully validated so that payment to suppliers can be authorized. The same precautions applicable to goods from external suppliers must also be applied to suppliers from inside the organization. Even such details as the project library, project coffee maker, project room furniture, and all the other minor bits and pieces should be accounted, maintained, and conserved.

Human Resource Control

Human resouces also need both regulation and conservation. Stewardship of human resources requires controlling and maintaining the growth and development of people. Projects provide particularly fertile ground for cultivating people. Because projects are unique, differing one from another in many ways, it is possible for people working on projects to gain a wide range of experience in a reasonably short time.

Measurement of physical resource conservation is accomplished through the familiar audit procedures. The measurement of human resource conservation is far more difficult. Such devices as employee appraisals, personnel performance indices, and screening methods for appointment, promotion, and retention are not particularly satisfactory devices for ensuring that the conservation function is being properly handled. The accounting profession has worked for some years on the development of human resource account, and while their efforts have produced some interesting ideas, human resource accounting is not well accepted by the accounting profession.

Financial Resource Control

Though accountants have not succeeded in developing acceptable methods for human resource accounting, their work on techniques for the conservation (and regulation) of financial resources have most certainly resulted in excellent tools for financial control. This is the best developed of the basic area needing control. It is difficult to separate those control mechanisms aimed at conservation of financial resources from those focused on regulating their use. Most financial controls do both. Capital investment, controls work to conserve the organization's assets by insisting that certain conditions be met before capital can be expended, and those same conditions usually regulate the use of capital to achieve the organization's goals of a high return on its investments.

The techniques of financial control, both conservation and regulation, are well known. They include current asset controls. These controls are exercised through a series of analyses and audits, conducted by the accounting/controller function for the most part. Representation of this function on the project team is mandatory. The structure of the techniques applied to projects does not differ appreciably from those applied to the general operation of the firm, but the context within which they are applied is quite different. One reason for the differences is that the project is accountable to an outsider - an external client, or another division of the parent firm, or both at the same time.

7.7 TYPES OF CONTROL PROCESSES

No matter what our purpose in controlling a project, there are three basic types of control mechanisms that we can use: cybernetic control, go/no-go control, and post control. In this section we will describe these three types of control and briefly discuss the information requirements of each.

7.7.1 Cybernetic Control

Cybernetic, or steering control is by far the most common type of control system. (Cyber is the Greek work from "helmsman.") The key feature of cybernetic control is its automatic operation.

Figure 7.3 shows that a system is operating with inputs being subjected to a process that transforms them into outputs. It is this system that we wish to control. In order to do so, we must monitor the system output. This function is

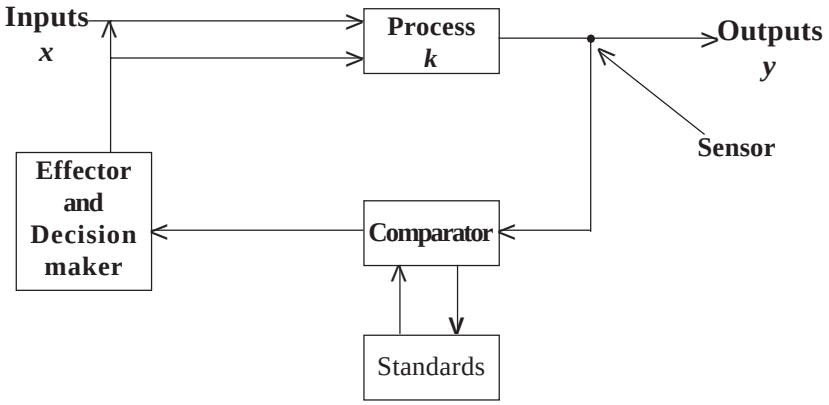

Figure 7.3: A cybernetic control system

performed by a sensor that measures one or more aspects of the output, presumably those aspects one wishes to control. Measurements taken by the sensor are transmitted to the comparator, which compares them with a set of predetermined standards. The difference between actual and standards. The difference between actual and standard is sent to the decision maker, which determines whether or not the difference is of sufficient size to deserve correction. If the difference is large enough to warrant action, a signal is sent to the effector, which acts on the process or on the inputs to produce output that conform more closely to the standard.

A cybernetic control system that acts to reduce deviations from standard is called a negative feedback loop. If the system output moves away from standard in one direction, the control mechanism acts to move it in the opposite direction. The speed or force with which the control operates is, in general, proportional to the size of the deviation from standard. The precise way in which the deviation is corrected depends on the nature of the operating system and the design of the controller.

7.7.2 Go/No-go Controls

Go/No-go controls take the form of testing to see if some specific precondition has been met. This type of control can be used on almost every aspect of a project. For many facets of performance, it is difficult to know that the predetermined specifications for project output have been met. The same is often true of the cost and time elements of the project plan.

It is, of course, necessary to exercise judgement in the use of go/no-go controls. Certain characteristics of output may be required to fall within precisely determined limits if the output is to be accepted by the client. Other characteristics may be less precisely defined. In regard to time and cost, there may be penalties associated with nonconformance with the approved plans. Penalty clauses that make late delivery costly for the producer are often included in the project contract. At times, early delivery can also carry a penalty. Cost overruns may be shared with the client or totally borne by the project.

The project plan, budget, and schedule are all control documents, so the project manager has a predesigned control system complete with pre-specified milestones as control checkpoints. Control can be exercised at any level of detail that is supported by detail in the plans, budgets, and schedules. The parts of a new jet engine, for instance, are individually checked for quality conformance. These are go/no-go controls. The part passes or it does not, and every part must pass its own go/no-go test before being used in an engine.

While cybernetic controls are automatic and will check the operating systems continuously or as often as designed to do so, go/no-go controls operate only when the controller uses them. In many cases, go/no-go controls function periodically, at regular, preset intervals. The intervals are usually determined by clock, calendar, or the operating cycles of some machine system. Such periodicity makes it easy to administer a control system, but it often allows errors to be compounded before they are detected. Things begin to go awry just after a quarterly progress check, for instance, and by the time the next quarterly check is made, some items may be seriously out of control. Project milestones do not occur at neat, periodic intervals; thus, controls should be linked to the actual plans and to the occurrence of real events, not simply to the calendar.

For an early warning system to work, it must be clearly understood that a messenger who brings bad news will not be shot, and that anyone caught sweeping problems and mistakes under the rug will be. An important rule for any subordinate is the Prime Law of Life on a project : "Never let the boss be surprised!"

7.7.3 Post-control

Post-controls (also "post-performance controls" or "post-project controls") are applied after the fact. One might draw parallels between post-control and "locking the barn after the horse has been stolen," but post-control is not a vain attempt to alter what has already occurred. Instead, it is a full recognition of George Santayana's observation that "Those who cannot remember the past are condemned to repeat it." Cybernetic and go/no-go controls are directed toward accomplishing the goals of an ongoing project. Post-control is directed toward improving the chances for future projects to meet their goals.

Post-control is applied through a relatively formal document that is usually constructed with four distinct sections.

a) **The Project Objectives :** The post-control will contain a description of the objectives of the project. Usually, this description is taken from the project proposal, and the entire proposal often appears as an appendix to the post-control report. As reported here, project objectives include the effects of all change orders issued and approved during the project.

   Because actual project performance depends in part of uncontrollable events) strikes, weather, failure of trusted suppliers, sudden loss of key employees, and other acts of God), the key initial assumptions made during the preparation of the project budget and schedule should be noted in this section. A certain amount of care must be taken in reporting these assumptions. They should not be written with a tone that makes them appear to be execuses for poor performance. While it is clearly the prerogative, if not the duty, of every project manager to politically protect himself, he or she should do so in moderation to be effective

b) **Milestones, Checkpoints, and Budgets :** This section starts with a full report of project performance against the planned schedule and budget. This can be prepared by combining and editing the various project status reports made during the project's life. Significant deviations of actual schedule and budget from planned schedule and budget should be highlighted. Explanations of why these, deviations occurred will be offered in the next section of the post-control report. Each deviation can be identified with a letter or number to index it to the explanations. Where the same explanation is associated with both a schedule and budget deviation, as well often be the case, the same identifier can be used.

c) **The Final Report on Project Results :** Note that in the previous section, when significant variations of actual from planned project performance were indicated, no distinction was made between favourable

and unfavourable variations. Like the tongue that invariably goes to the sore tooth, project managers focus their attention on trouble. While this is quite natural, it leads to complete documentation on why some things went wrong and title or no documentation on why some things went particularly well. Both sides, the good and the bad, should be chronicled here.

Not only do most projects result in outputs that are more or less satisfactory, most projects operate with a process that is more or less satisfactory. The concern here is not on what the project did but rather on how it did it. Basically descriptive, this part of the final report should cover project organization, an explanation of the methods used to plan and direct the project, and a review of the communication networks, monitoring systems, and control methods, as well as a discussion of intraproject interactions between the various working groups.

Recommendations for Performance and Process Improvement: The culmination of the post-control report is a set of recommendations covering the ways future projects for improving. Many of the explanations appearing in the previous section are related to one-time happenings, sickness, weather, strikes, the appearance of a new technology, etc., that themselves are not apt to affect future project-although other different one-time events may effect them. But some of the deviations from plan were caused by happenings that are very likely to recur. Provision for such things can be factored into future project plans, thereby adding to predictability and control.

Just as important, the process of organizing and conducting projects can be improved by recommending the continuation of managerial methods and organizational systems that appear to effect, together with the alteration of practices and procedures that do not. In this way, the conduct of projects will become smoother, just as the likelihood of achieving good results, on time and on cost, is increased.

Activity 2

President of an MNC has asked you to develop control system for his organization:

a) List out the activities that you would cover while developing control system for the organization.

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b) List out the various assets of the organization that would require control.

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c) List out the three basic types of control mechanisms that you would employ in the organization.

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7.8 DESIGN OF CONTROL SYSTEMS

Irrespective of the type of control used, there are some important questions to be answered while designing any control system: who sets the standards? How realistic are the standards? How clear are they? Will they achieve the project's goals? What output, activities, behaviours should be monitored? Should we monitor people? What kinds of sensors should be used? Where should they be placed? How timely must be monitoring be? How rapidly must it be reported? How accurate must sensors be?

If the control system is to be acceptable to those who will use it and those who will be controlled by it, the system must be designed so that it appears to be sensible. Standards must be achievable by the mechanical systems used. Control limits must be appropriate to the needs of the client, that is, not merely set to show "how good we are." Like punishment, rewards and penalties should "fit the crime."

In addition to being sensible, a good control system should also possess some other characteristics as set out below :

- The system should be flexible. Where possible, it should be able to react to and report unforseen changes in system performance.
- The system should be cost-effective. The cost of control should never exceed the value of control. As we noted above, control is not always less expensive than scrap.
- The control system must be truly useful. It must satisfy the real needs of the project, not the whims of the project manager.
- The system must operate in a timely manner. Problems must be reported while there is still time to do something about them, and before they become large enough to destroy the project.
- Sensors and monitors should be sufficiently accurate and precise to control the project within limits that are truly functional for the client and the parent organization.
- The system should be as simple to operate as possible.
- The control system should be easy to maintain. Further, the control system should signal the overall controller if it goes out of order.
- The system should be capable of being extended or otherwise altered.
- Control systems should be fully documented when installed and the documentation should include a complete training program in system operation.

No matter how designed, all of the control systems described above use feedback as a control process. Let us now consider some more specific aspects of control. To a large extent, the Project Manager is trying to anticipate problems or catch them just as they begin to occur. The Project Manager wants to keep the project out of trouble because upper management often bases an incremental funding decision on a review of the project. This review typically follows some particular milestone and, if acceptable, leads to a follow-on authorization to proceed to the next review point. If all is not going well, other technological alternatives may be recommended; or if things are going badly, the project may be terminated. Thus, the project manager must monitor and control the project quite closely.

The control of performance, cost, and time usually requires different input data. To control performance, the project manager may need such specific documentation as engineering change notices, test results, quality checks,

rework tickets, scrap rates, and maintenance activities. For cost control, the manager compares budgets to actual cash flows, purchase orders, labour hour charges, amount of overtime worked, absenteeism, accounting variance reports, accounting projections, income reports, cost exception reports, and the like. To control the schedule, the project manager examines bench mark reports, periodic activity and status reports, exception reports, PERT/CPM networks, Gantt charts, the master project schedule, earned value graphs, and probably reviews the Action Plans.

Some of the most important analytical tools available to the project manager to use in controlling the project are variance analysis and trend projection.

Earned value analysis was also described earlier. On occasion it may be worthwhile, particularly on large projects for the project manager to calculate a set of critical ratios for all project activities. The critical ratio is.

(Actual Progress/Scheduled Progress) x (Budgeted Cost/Actual Cost)

If this ratio is exactly one, then the activity is probably on target. If the ratio differs from one, then the activity may need to be investigated. The closer the ratio is to one, the less important is the investigation. Consider Table 7.1 for example.

We can see that the first task is being scheduled but below budget. If delay is no problem for this activity, the project manager need take no action. The second task is on budget but its physical progress is lagging. Even if there is slackness in the activity, the budget will probably be overrun. The third task is on schedule but cost is running higher than budget, creating another probable cost overrun. The fourth task is on budget but ahead of schedule. A cost saving may result. Finally, the fifth task is on schedule and is running under budget, another probable cost saving.

Task 4 and 5 have critical ratios greater than one and might not concern some project manager but the thoughtful manager would like to know why they are doing so well (and the project manager may also want to check the information system to validate the unexpectedly favourable findings). The second and third activities need attention, and the first task may need attention also. The project manager may set some critical-ratio control limits intuitively.

Table 7.1: (Actual Progress/Scheduled Progress) x (Budget Cost/Actual Cost)

Task Number	Actual Progress		Scheduled Progress		Budgeted Cost		Actual Cost		Critical Ratio
1	(2	/	3)	%	(6	/	4)	=	1.0
2	(2	/	3)	%	(6	/	4)	=	.67
3	(3	/	3)	%	(4	/	6)	=	.67
4	(3	/	2)	%	(6	/	6)	=	1.5
5	(3	/	3)	%	(6	/	4)	=	1.5

7.9 CONTROL OF CREATIVE ACTIVITIES

Some brief attention should be paid to the special case of controlling research and development projects, design projects, and similar processes that depend intimately on the creativity of individuals and teams. First, the more creativity involved, the greater the degree of uncertainty surrounding outcomes. Second,

too much control tends to inhibit creativity. Control is not necessarily the enemy of creativity; nor, popular myth to the contrary, does creative activity imply complete uncertainty. While the exact outcomes of creative activity may be more or less uncertain, the process of getting the outcome is usually not uncertain.

In order to control creative projects, the project manager must adopt one or some combination of three general approaches to the problem: (1) progress review, (2) personnel reassignment, and (3) control of input resources.

7.10 PROGRESS REVIEW

The progress review focuses on the process of reaching outcomes rather than on the outcomes per se. Because the outcomes are partially dependent on the process used to achieve them - uncertain though they may be - the process is subjected to control. For example, in the case of research projects the researcher cannot be held responsible for the outcome of the research, but can most certainly be held responsible for adherence to the research proposal, the budget, and the schedule. The process is controllable even if the precise results are not.

7.11 PERSONNEL REASSIGNMENT

This type of control operates in a very straightforward way. Individuals who are productive are retained. Those who are not to be retained are moved to other jobs or to other organizations. Problems with this technique can arise because it is easy to create an elite group. While the favoured few are highly motivated to further achievement, everyone else tends to be demotivated. It is also important not to apply control with too fine an edge. While it is not particularly difficult to identify those who falls in the top and bottom quartiles of productivity, it is usually quite hard to make clear distinctions between people in the middle quartiles.

7.12 CONTROL OF INPUT RESOURCES

In this case, the focus is of efficiency. The ability to manipulate input resources carries with it considerable control over output. Obviously, efficiency is not synonymous with creativity, but the converse is equally untrue. Creativity is not synonymous with extravagant use of resources.

The results flowing from creative activity tend to arrive in batches. Considerable resource expenditure may occur with no visible results, but then, seemingly all of a sudden, many outcomes may be delivered. The milestones for application of resource control must, therefore, be chosen with great care. The controller who decides to withhold resources just before the fruition of a research project is apt to become an ex-controller.

Sound judgement argues for some blend of these three approaches when controlling creative projects. The first and third approaches concentrate on process because process is observable and can be affected. But process is not the matter of moment; results are. The second approach requires us to measure (or at least to recognize) output when it occurs. This is often quite difficult. Thus, the wise project manager will use all three approaches: checking process and method, manipulating resources, and culling those who cannot or do not produce.

7.13 SUMMARY

Project is a set of complex interelated activities. A bottleneck at any one of the stages has an impact on the completion schedule of other stages, therefore for any project a monitoring system is a must. The frequency and the type of monitoring as well as data collection for monitoring will vary from project to project. Project monitoring reports are basically of three types 1) Routine, 2) Exception, 3) Special Analysis.

Project control is the act of comparing the planned performance with the actual and reducing the difference between the two. Project control has three domains 1) Physical Asset Control, 2) Human Resource Control, 3) Financial Resource Control.

7.14 SELF ASSESSMENT QUESTIONS

1) What is the purpose of control? To what is it directed?
2) What are the three main types of control systems? What questions should a control system answer?
3) What tools are available to the project manager to use in controlling a project? Identify some characteristics of a good control system.
4) What is the mathematical expression for the critical ratio? What does it tell a manager?
5) How might the project manager integrate the various control tools into a project control system?
6) How could a feedback control system be implemented in project management to anticipate client problems?
7) Define monitoring. Are there any additional activities that should be part of the monitoring function?
8) Calculate the critical ratios for the following activities and indicate which activities are probably on target and which need to be investigated.

Activity	Actual Progress	Scheduled Progress	Budgeted Cost	Actual Cost
A	4 days	4 days	Rs. 60	Rs. 40
B	3 days	2 days	Rs. 50	Rs. 50
C	2 days	3 days	Rs. 30	Rs. 20
D	1 day	1 day	Rs. 20	Rs. 30
E	2 days	4 days	Rs. 25	Rs. 25

9) Give the following information, which activities are on time, which are early, and which are behind schedule?

Activity	Budgeted Cost	Actual Cost	Critical Ration
A	Rs. 60	Rs. 40	1.0
B	Rs. 25	Rs. 50	0.5
C	Rs. 45	Rs. 30	1.5
D	Rs. 20	Rs. 20	1.5
E	Rs. 50	Rs. 50	0.67

7.15 FURTHER READINGS

Cleland, D.I., and W.R. King, "*Systems Analysis and Project management*," MC Graw Mill, 1983.

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