CONTROL OF PROJECTS - A CYBERNETIC CONTROL

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Abstract: *Control is the last element in the implementation cycle 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 enough 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. In essence control is the act of reducing the difference between plan and reality. Control is focused of the three elements of project-performance, cost and time. The project manager is constantly concerned with these three aspects of the project. Is the project delivering what it promised to deliver or more? Is it making delivery at or below the promised cost? Is it making delivery at or before the promised time? It is strangely easy to lose sight of these fundamental targets, especially in large projects with a wealth of detail and a great number of subprojects. Large projects develop their own momentum and tend to get out of hand, going their own way independent of the wishes of the project manager and the intent of the proposal.*

Key words: cybernetic control; negative feedback loop; first order control system; second-order control system; third-order control system

In project management field, there are few things that can cause a project to require the control performance, costs or time.

Performance:

- Unexpected technical problems arise.
- Insufficient resources are available when needed.
- Insurmountable technical difficulties are present.
- Quality or reliability problems occur.
- Client requires changes in system specifications.
- Inter functional complications arise.
- Technological breakthroughs affect the project.

Cost:

- Technical difficulties require more resources.
- The scope of the work increases.
- Initial bids or estimates were too low.
- Reporting was poor or untimely.
- Budgeting was inadequate.
- Corrective control was not exercised in time.
- Input price changes occurred.

Time:

- Technical difficulties took longer than planned to solve.
- Initial time estimates were optimistic.

- Task sequencing was incorrect.
- Required inputs of material, personnel, or equipment were unavailable when needed.
- Necessary preceding tasks were incomplete.
- Customer-generated change orders required rework.
- Governmental regulations were altered.

And these are only a few of the relatively "mechanistic" problems that project control can occur. Actually, there are no purely mechanistic problems on projects. All problems have a human element, too. For example, humans, by action or inaction, set in motion a chain of events that leads to a failure to budget adequately, creates a quality problem, leads the project down to a technically difficult path, or fails to note a change in government regulations. If, by chance, some of these or other things happen (as a result of human action or not), humans are affected by them. Frustration, pleasure, determination, hopelessness, anger and may other emotions arise during the course of a project. They affect the work of the individuals who feel them – for better or worse. It is over this welter of confusion, emotion, fallibility, and general cussedness that the PM tries to exert control.

All of these problems, always combinations of the human and mechanistic, call for intervention and control by the project manager. There are infinite "slips" especially in projects where the technology or deliverables are new and unfamiliar, and project managers, like most managers, find control is a difficult function to perform. There are several reasons why this is so. One of the main reasons is that project managers, again like most managers, do not discover problems. In systems as complex as projects, the task of defining the problems is formidable, and thus knowing what to control is not a simple task. Another reason control is difficult is because, in spite of an almost universal need to blame some person for any trouble, it is often almost impossible to know if a problem resulted from human error or from the random application of Murphy's Law.

Project managers also find it tough to exercise control because the project team, even on large projects, is an "in-group". It is "we" while outsiders are "they". It is usually hard to criticize friends, to subject them to control. Further, many project managers see control as an ad-hoc process. Each need to exercise control is seen as a unique event, rather than as one instance of an ongoing and recurring process. Whitten offers the observation that projects are drifting out of control if the achievement of milestones is threatened. He also offers some guidelines on how to resolve this problem and bring the project back in control.

Because control of projects is such a mixture of feeling and fact of human and mechanism, of causation and random chance, we must approach the subject in an extremely orderly way. This why we start by examining the general purposes of control. Then we consider the basic structure of the process of control. We do this by describing control theory in the form of a cybernetic control loop. While most projects offer little opportunity for the actual application of automatic feedback loops, the system provides us with a comprehensive but reasonably simple illustration of all the elements necessary to control any system. From this model, we then turn to the types of control that are most often applied to projects. The design of control systems is discussed as are the impacts that various types of controls tend to have on the humans being controlled. The specific requirement of "balance" in a control system is also covered, as are two special control problems: control of creative activities, and control of change.

The process of controlling a project (or any system) is far more complex than simply waiting for something to go wrong and the, if possible, fixing it. We must decide at what points in the project we will try to exert control, what is to be controlled, how it will be measured, how much deviation from plan will be tolerated before we act, what kinds of interventions should be used, and how to spot and correct potential deviations before they occur. In order to keep these and other such issues sorted out, it is helpful to begin a consideration of control with a brief exposition on the theory of control,

No matter what our purpose in controlling a project, there are three basic types of control mechanisms we can use: cybernetic control, go/no-go control and post-control. We will describe the first type and briefly discuss the information requirements of each. While few cybernetic control systems are used for project control, we will describe them here because they clearly delineate the elements that must be present in any control system, as well as the information requirements of control systems.

Cybernetic control

Cybernetic or steering control is by far the most common type of control system. The key feature of cybernetic control is its automatic operation. Consider the diagrammatic model of a cybernetic control system shown in figure 1. As Figure 1 shows, 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 performed by sensors that measure one or more aspects of the output, presumably those aspects one wishes to control. Measurements taken by a sensor are transmitted to the comparator, which compares them with a set of predetermined 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 effectors, which acts on the process or on the inputs to produce outputs 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 the 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 the standard. The precise way in which the deviation is corrected depends on the nature of the operating system and the design of the controller. Figure 2 illustrates three different response patterns. Response path A is direct and rapid, while path B is more gradual. Path C shows oscillations of decreasing amplitude. An aircraft suddenly deflected from a stable flight path would tend to recover by following pattern C.

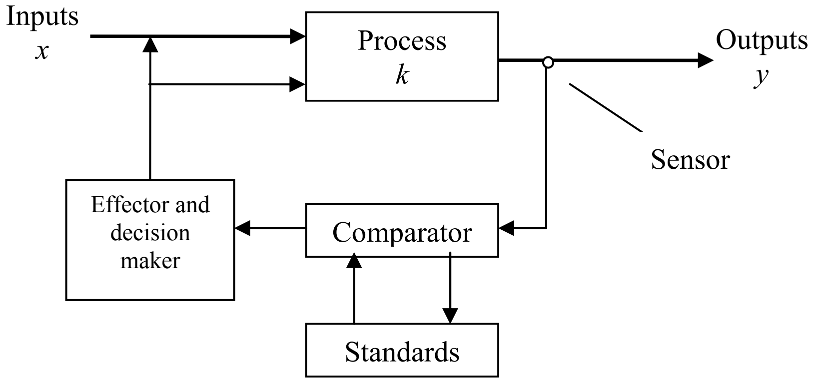

Figure 1. A cybernetic control system

Types of cybernetic control systems

Cybernetic controls come in three varieties, or *orders*, differing in the sophistication with which standards are set. Figure 1 show a simple, *first order control system*, a goal seeking device. The standard is set and there is no provision made for altering it except by intervention from the outside. The common thermostat is a time-worn example of a first-order controller. One sets the standard temperature and the heating and air-conditioning systems operate to maintain it.

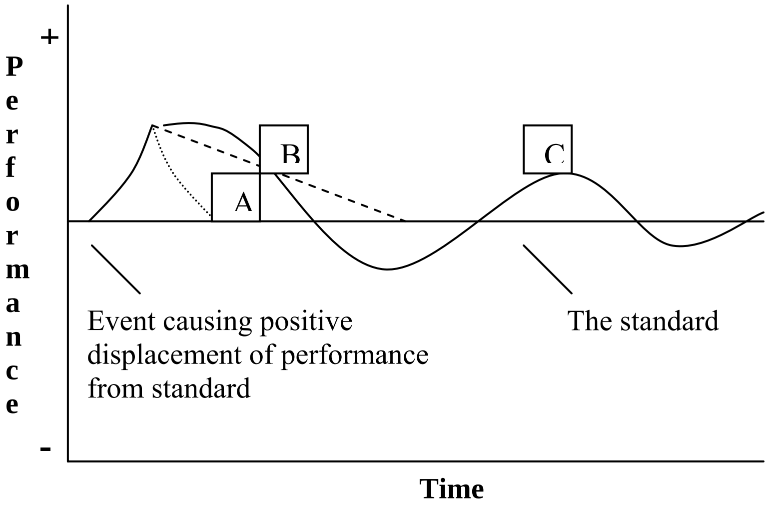

Figure 2. Typical paths for correction or deviation of performance from standard

Figure 3 show a *second-order* control system. This device can alter the system standards according to some predetermined set of rules or program. The complexity of second-order systems can vary widely. The addition of a clock to a thermostat to allow it to maintain different standards during day and night makes the thermostat a second-order controller. Am interactive computer program may alter its responses according to a complex set of pre-programmed rules, but it is still only a second-order system. Many industrial projects involve second-order controllers – for example, robot installations, flexible manufacturing systems, and automated record keeping or inventory systems.

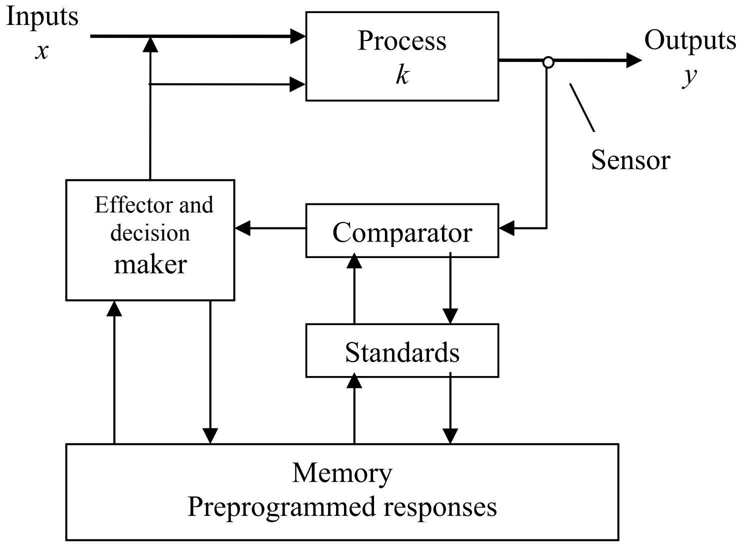

Figure 3. A second-order feedback system- preprogrammed goal changer

A *third-order* control system (Figure 4) can change its goals without specific preprogramming. It can reflect on system performance and decide to act in ways that are not contained in its instructions. Third-order systems have reflective consciousness and, thus, must contain humans. Note that a second-order controller can be programmed to recognize patterns and to react to patterns in specific ways. Such systems are said to "learn". Third-order systems can learn without explicit preprogramming and therefore can alter their actions on the basis of thought or whim. An advantage of third-order controllers is that they can deal with the unforeseen and unexpected. A disadvantage is that, because they contain human elements, they may lack predictability and reliability. Third order systems are of great interest to the PM for reasons we now discuss.

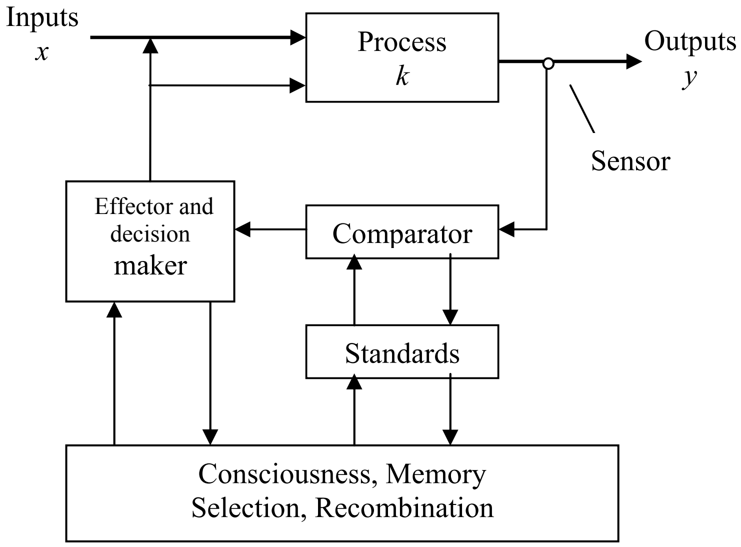

Figure 4. A third-order feedback system – reflective goal changer

Information requirements for cybernetic controllers

In order to establish total control over a system, a controller must be able to take a counter-action for every action the system can take. This statement is a rough paraphrase of Ashby's Law of Requisite Variety. This implies that the PM\ controller is aware of the system's full capabilities. For complex systems, particularly those containing a human element, this is simply not possible. Thus we need a strategy to aid the PM in developing a control system. One such strategy is to use a cost\benefit approach to control – to control those aspects of the system for which the expected benefits of control are greater than the expected costs. We are reminded of a firm that manufactured saw blades. It set up a project to reduce scrap losses for the high-cost steel from which the blades were made. At the end of the one year project, the firm had completed the project – cost $ 9700, savings $4240. (Of course, if the savings were to be repeated for several years, the rate of return on the project would be acceptable. The president of the firm, however, thought that the savings would decline and disappear when the project ended.)

Relatively few elements of a project (as opposed to the elements of a system that operates more or less continuously) are subject to automatic control. An examination of the details of an action plan will reveal which of the project's tasks are largely mechanistic and represent continuous types of systems. If such systems exist, and if they operate across a sufficient time period to justify the initial expense of creating an automatic control, then a cybernetic controller is useful.

Given the decisions about what to control, the information requirements of a cybernetic controller are easy to describe, if not to meet. First, the PM must decide precisely what characteristics of an output (interim output or final output) are to be controlled. Second, standards must be set for each characteristic. Third, sensors must be acquired that will measure those characteristics at the desired level of precision. Fourth, these measurements must be transformed into a signal that can be compared to a standard signal. Fifth, the difference between the two is sent to the decision maker, which detects it, if it is sufficiently large, and sixth, transmits a signal to the effectors that causes the operating system to react in a way that will counteract the deviation from standard. If the control system is designed to allow the effectors to take one or more of several actions, an additional piece of information is needed. There must be built-in criteria that instruct the effectors on which action(s) to take.

Knowledge of cybernetic control is important because all control systems are merely variants, extensions or non-automatic modifications of such controls. Because most projects have relatively few mechanistic elements that can be subjected to classic cybernetic controls, this concept of control is best applied to tracking the system and automatically notifying the project manager when things threaten to get out of control.

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