Is There an Underlying Theory of Software Project Management?[1]

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Abstract: Traditional project management methods are based on scientific principles considered "normal science" but lack a theoretical basis for this approach. [35, 36, 69] These principles result in linear stepwise refinement of the project's outcomes by applying the planning-as-management paradigm. Linear feedback methods adjust plans made in this paradigm. These plans cannot cope with the multiple interacting and continuously changing technology and market forces. They behave as a linear, deterministic, Closed-Loop control system.

A Closed-Loop adaptive control paradigm parallels this approach and agile project management methods. From these, a comparison is made between project management practices and the tenets of agile development processes in terms of feedback control and emergent solutions with a control system capable of adjusting to the changes brought about by changes in the dynamics of the process, disturbances, or some other cause not established in the original plan.

This paper suggests that when managing in the presence of uncertainties that create a risk to project success, adaptive control theory may be better suited as a model for project management in a rapidly changing, dynamically evolving network of statistical processes than traditional linear approaches.

Introduction

> Because large-scale software projects increasingly affect the public good, the standard *science* paradigm is insufficient to model their complexity and potential consequences. The post-normal *science* paradigm offers a better fit, using a robust management approach predicated on a risk-taking ethic. [13]

Project success is a frequent topic in project management, but it needs to be better understood in how to reach that success. [770] Since the early days of the software industry, managing software development projects has been fraught with risk to project success created by

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uncertainty. [2] While the technical content of products and the methods used to build those products has changed over time, the fundamental issues determining a project's success or failure have remained constant.

Traditional program control systems must be better suited to respond to changes encountered in software development projects. In the development software intensive systems, research shows there are four primary root causes of project failure:

Unrealistic performance expectations,

Unrealistic cost and schedule estimates based on inadequate risk-adjusted growth models,

Inadequate assessment of risk and unmitigated exposure to these risks without proper handling plans,

Unanticipated technical issues without alternative plans and solutions to maintain the effectiveness of the project's planned progress.

In the presence of these conditions, the success rate of software development could have been better when applying traditional methods in complex development software development project environments. [330] The conventional, linear, stepwise approach to software development has its roots in the project management methods of the 1970s. It was clear then, and has become clear today, that this approach to managing projects is inappropriate in many domains. [66, 67] The project management literature needs to include an answer to the question - *is there an underlying theory of project management appropriate for complex, Software Intensive Systems development projects*? [53], [77]

A secondary question is - can a theory be constructed consistent with adaptive feedforward control systems and agile development processes currently in use in manufacturing, science, engineering, economics, biology, and ecology?

This paper describes an approach to applying theories in other domains that match the behavioral aspects of software project management. The theory of Closed Loop Adaptive Control Systems is one choice. Performance references, control loops, and stochastic processes have similar paradigms in dynamics systems and project management. In addition, the theory of complex adaptive systems and adaptive controls for those systems have a similar paradigm in "agile" software development.

[2] Poor management practices are one source of project failure. This paper does not address these management processes, but instead addresses the failure modes from uncertainties that create risk encountered on the project. Poor management is a risk, but research shows that unaddressed *reducible* (Epistemic) and *irreducible* (Aleatory) uncertainties are the primary source of project failure once management processes have been addressed.

The development of complex Software Intensive System of Systems (SISoS) [3] requires substantial creativity and innovation as well as frameworks for engineering and governing the development work. Predicting the outcome of the development work with a fixed or short set of resources and deadlines takes time and effort. When there are external market forces, incomplete, evolving or ill-formed requirements, and changing stakeholder needs, there are three questions for consideration:

What technical development and project management methods are appropriate?

What theoretical aspects of project management can be applied in this environment?

What gaps exist in current project management methods that can be closed to increase the probability of success in the presence of uncertainty?

Project Management Theory

> The current literature describes project management in terms of initiating, planning, executing, monitoring, controlling and closing the project. This literature often assumes project management takes place within the paradigm of *management-as-planning*.

This paradigm has causal connections between management actions and project outcomes. This view is that project management is an instrument to achieve a goal rather than an individual organization. [4] Feedback from this planning process is based on after-the-fact variance detection. As a feedback control system, gaps in the feedback include delays used to correct the plans and execution before the deviation grows too large, adaptive planning through adaptive feedback loops, and feed-forward controls to direct the execution of the project based on inputs about future needs of the stakeholders.

In the literature, project management methods are reduced to stable, technical, and linear processes. [5] The impact on the project from external forces or problems within the project is given little attention. It is assumed in this traditional model that "change" is an undesirable thing,

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[3] Software Intensive System of Systems can be defined using IEEE 1471 to express the system and its evolution, starting with the communication among the system stakeholders. A critical success factor is the evaluation and comparison of architectures in a consistent manner to establish the framework for planning, managing, and executing the activities needed for the system's deployment. These persistent characteristics and supporting principles guide the verification process of the system's implementation compliance with the architectural description.

[4] The origins of industrial society can explain why much project management theory assumes that projects take place within a single organization. This basic assumption is out of step with post-industrial society's joint ventures, and strategic collaborations.

[5] Linear project management models are sometimes referred to as *waterfall* models. In these models it is assumed that each phase of the project is completed in a fixed sequence, followed by the next logical phase. In the Agile methods the linearity still exists, since the statistical processes and the resulting probabilistic outcomes are formally addressed in the management control system.

when in fact, change in the business systems world is not only natural but desirable. The conflict between "managing in the presence of change" and "managing change" by attempting to control it is the source of many gaps between traditional and agile project management.

An approach to defining a project management theory can be found in [48]. It is conjectured that a well-functioning bureaucracy, aided by scientific planning tools, can efficiently deal with a project through these "normal-science" methods. This approach assumes projects are carried out under conditions of complete rationality. [6] It also assumes that projects are repetitive, with their requirements and stakeholder needs to be built on existing knowledge from past performance. [7]

The majority of software development projects are not conducted under conditions of rationality. Software projects are not repetitive, stable, statistically stationary, or linear. They are unique, driven by emerging requirements, technology, and market forces, and contain many non-linear activities and stochastic processes. Technical development is complex; the exact business and technical outcome takes planning time. The methods used to manage the work may need to be more manageable. Projects are often subjected to forces outside the control of the project manager, engineers, and stakeholders.

More importantly, developing and deploying complex technical projects creates a non-linear feedback loop between the product and the deployment process. Once the project outcomes are deployed, the users have new and sometimes disruptive requirements - once they know and understand how the delivered system works.

A framework for examining this situation can be found in a similar approach to managing systems engineering activities. [63]

Figure 1 presents an overview of the elements and dimensions of project management. The "control system" involved in project management is not shown since this is a static view of the elements and their interactions. The critical aspect of **Figure 1** is the connection between the components of the problem domain and the solution domain. As the problem grows, the linear non-adaptive approaches to managing work in uncertainty have a lower probability of success.

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6 All rational action embodies some precautionary principle. What kind of harm can be averted? What kinds of costs are willing to be incurred by the stakeholders? In the rational context, risks can be pre-identified, production rates are known, defects can be statistically analyzed, and requirements can be elicited up front.

7 This can be the case when *Reference Class Forecasting* is in place. But many times the needed information to construct the *reference class* was never gathered from past projects. As well *parametric* and *model based* processes, like Agile Function Point Analysis are not used. In the absence of this data, making informed decisions in the presence of uncertainty will be difficult.

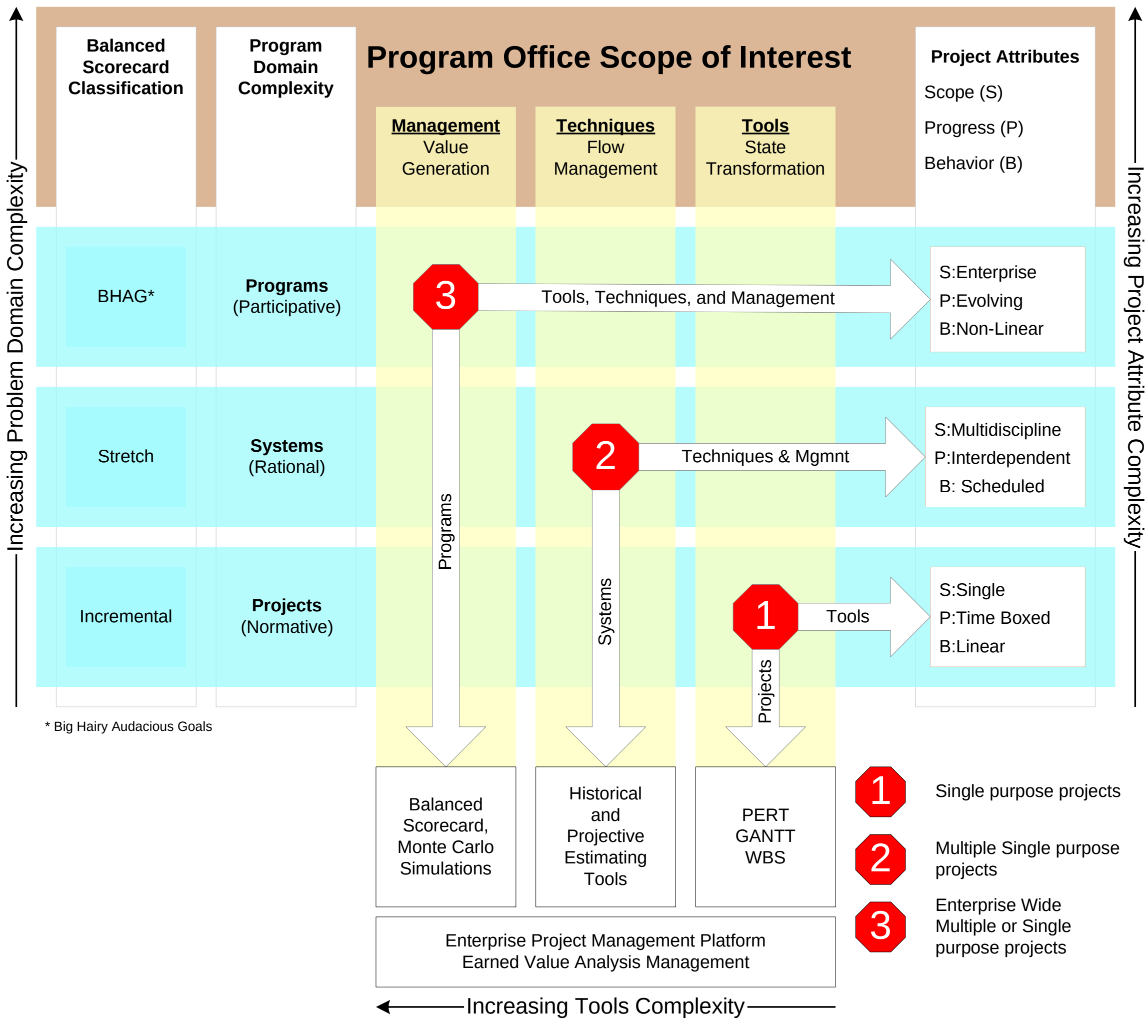

Figure 1 - Dimensions of Complex Project Management independent of the actual control system used to manage the project. As complexity increases, the non-linear dynamics of the project and its management demand methods other than traditional planning and control. Statistical process control can address the issues using adaptive behavior feed-forward control.

Managing In the Presence of Uncertainty

All project work is performed in the presence of uncertainty. Traditional and Agile project management needs the means to maintain the stability of project performance in the presence of this uncertainty. When a disruptive event occurs, the project performance is disrupted, and the project must be re-planned at some level to correct the source of the disruption. The level can be at the lowest task level or the highest capabilities level. But no matter the level, change must be made to the project's plan in the presence of disruption.

Information is needed to manage the presence of uncertainty and the disruptive conditions the uncertainty creates. To drive its success, two issues must be addressed:

The observed outcomes of the project must provide the information. This is a *state estimation* problem.

Second, is the formulation of the *stochastic control* problem and the solution to the situation in the form of a closed-loop control system.

Three aspects of project performance management using any control system, traditional, agile, or adaptive, must provide guidance:

Estimation - linear estimation, non-linear information, and uncertain information.

Identification - of the parameters that impact the performance of the project.

Control - of these parameters to maintain the desired project performance.

The normative advice provided by traditional project management bodies of knowledge - planning, execution, and control - forms a Closed-Loop linear system. This advice is usually based on *rules* that specify which choices will maximize benefits to the participants. Normative theory suggests that a project is a series of sequentially related activities.

Beyond this normative approach, project management is a set of multiple interacting interdependent random activities behaving non-linear and adaptively. This is an operational definition of a Complex Adaptive System (CAS) that can be applied to modeling project management activities. Adaptive control systems offer a simpler model without CAS's complex and intractable mathematics. The distinctions between traditional and adaptive management can be summarized in **Figure 2** - Distinctions between Traditional and Adaptive Project Management methods. Applying these methods depends on the project's complexity and the dynamic behaviors of those complexities.

A Focus on Information Technology Project Management

Software Intensive Systems (SIS) [8] projects traditionally use formal management processes for the system's acquisition or development, deployment, and operation that emphasize in-depth planning. This approach organizes work into phases separated by decision points. Supporters of this approach emphasize that changes made early in the project can be less expensive than changes made late in the project.

SIS can be found in a variety of business and technical domains

[8] A software-intensive system is any system where software contributes important influences on the system's design, construction, deployment, and evolution. [from ISO/IEC/IEEE 42010:2011].

Business information systems - the US Government is one of the prominent consumers of ERP systems, finance systems, logistics systems, personnel, and payrolls

Network-reliant systems are the traditional command and control systems found in industry and government, where data is exchanged between disparate physical systems, with large amounts of data used to assist humans in awareness and decision-making processes.

Infrastructure systems - enterprise systems of related business, embedded, or other systems. This infrastructure provides the equipment and capability needed for integrated complex systems to function correctly.

Embedded systems - systems that interact with the physical through sensors, displays, and human command and control for control applications in industry, equipment, and products used to control other systems.

> The embedded systems market is 100 times larger than the desktop software market. Only some new products reach the market with embedded systems. The number of embedded systems in a product range from one to tens in consumer products and hundreds in large professional and industrial systems.
>
> Embedded systems are an essential business domain for applying the adaptive project control paradigm based on Agile development processes, including capabilities planning, programmatic and technical estimating, risk management, and program performance management. [Embedded Systems Roadmap 2002, published by the Technology Foundation of the Netherlands (STW)]

In the past, when waterfall [9] was used as the approach to SIS, this framework *contained* several erroneous assumptions that negatively impacted SIS projects:

Planning - the assumption that it is possible to produce a plan so that its implementation is merely a matter of executing a defined set of tasks in a predefined order.

Plans for complex projects rarely turn out to be good enough to remain intact throughout the project life cycle.

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[9] The term *waterfall* has been used many times as a *strawman* by the agile community. In fact very few pure waterfall projects exist today. This is not to say there are not abuses of the concept of waterfall - sequential development based on the simple algorithm `REPEAT [Design, Code, Test] UNTIL Money = 0`. In practice, development and deployment processes based on incremental and iterative methodologies are the norm. The literature contains numerous references and guidelines to this iterative project management approach dating back to the 1980's [66].

Standard practices include continuous re-planning, re-adjusting of priorities, and re-analyzing the consequences of these changes.

Unanticipated problems are the norm rather than the exception.

Change - It is not possible to protect against late changes.

All businesses face late changing competitive environments.

The window of business opportunity opens and closes at the whim of the market, not the direction of the project manager.

Stability - Management usually wants a plan to which it can commit. By making this commitment, they give up the ability to take advantage of fortuitous developments in the business and technology environment [71].

In a financial setting, this is the *option value* of the decision.

Deferring decisions to take advantage of new information and opportunities is rarely considered in IT projects [72].

Adaptive Control Systems and Agile Methods

> In adaptive control systems, dynamic characteristics are not constant because of changes in the parameters and changes in the environment. The effects of small changes on the dynamic characteristics may be attenuated in a feedback control system. If the changes are significant, a system must be in place with the ability to adapt. The adaption implies self-adjustment or self-modifying by the unpredictable changes in the conditions. The dynamic characteristics must be identified in adaptive systems to adjust the control parameters to maintain optimum performance. Such systems accommodate the uncertainties found in all project work, especially agile development, where requirements are emerging. [56]

"To adapt" means to change a behavior to conform to new circumstances. Intuitively, an adaptive controller is a control system that can modify its behavior in response to changes in the dynamics of the process and the character of the disturbances. [31]

Agile processes emphasize rapid and flexible adaptation to changes in the process, the product, and the development environment [4]. This is a very general definition and, therefore only very useful with some specific context - which will be developed below. Even agile processes are driven by linear, non-statistical algorithms and need the statistical aspects of the underlying processes. To be adaptive, the control loop needs to

Provide control for non-linear processes.

Adaptively tune the control algorithm with no interruption to the controlled process.

Be capable of fast response to changing conditions.

Before establishing this context, agile methods include four significant attributes. They are:

Incremental and Evolutionary - allowing adaptation to both internal and external events.

Modular and Lean - allowing components of the process to come and go depending on the specific needs of the participants and stakeholders.

Time-Based - built on iterative, nestled, and concurrent work cycles.

Self-Organizing - in the sense that normative guides have little to offer regarding structure and control. Agile methods rely primarily on heuristics and participative processes rather than normative, rational methods and guidelines.

Project Management as a "Control System"

> The general requirements for a control system start with it being stable. This is a primary requirement. In addition to this absolute stability, the control system must have reasonable relative stability. That is, the speed of response must be fast. The control system must be capable of reducing errors to near zero or some small tolerable value. The requirements of reasonable relative stability and steady-state accuracy are usually incompatible. In designing the control system, it is necessary to make the most effective compromise between these two requirements. [56]

Project management vocabulary [17] is similar to control systems' vocabulary [43, 52]. With these terms, it will be clear that Project Management can be modeled as a control system. With this modeling comes the ability to assess the components of project management, the control system that provides feedback and corrective action for maintaining the project's performance.

Most importantly for this paper, the basis for introducing the notion of Adaptive controls to manage projects in the presence of uncertainty and emergent behavior, often found in Agile software development domains.

These terms include **Figure 3** - Project Management and Control Systems Vocabulary. Making these connections is the basis of applying adaptive controls in the project management domain.

Project Management as a Control System

Control systems are important in engineering, science, economics, and biological systems. They also play an important role is creating *models* of other general systems, either as models of these systems or as metaphors of the models of these systems. [8].

Early control systems were based on linear feedback models. As the entities being controlled became more complex, the classical control theory, which dealt with single input and single output systems, became less useful. Multiple input and output systems now dominate control systems theory and practice. Recently adaptive and optimal control systems have been developed. Applications of modern control theory to non-physical fields are also the norm. Biology, economics, sociology, and other dynamic systems are common practices. Complex Adaptive Systems is a popular topic today.

This section aims to construct a connection between control systems, especially adaptive control systems, and project management.

Basic Problems in Control System Design

Before moving forward, some comparisons between control systems and project management systems will be helpful. Project management is a Closed Loop Control system.

A closed-loop control process assures that a system performs within control limits. In closed-loop control, the system's output is fed back directly to change the system's inputs. An example of Closed-Loop control is how a thermostat works with a furnace to control room temperature. Closed loop control starts with an explicit objective (e.g., the desired room temperature), a measure of the status of the system against that objective system (e.g., the difference between the actual and desired room temperatures), and a mechanism for adjusting the system's inputs to correct the difference and meet the objective (e.g., turning the furnace on or off).

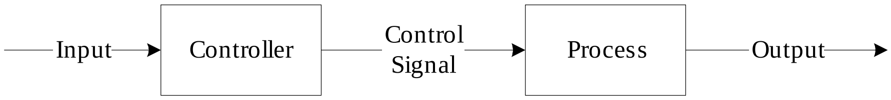
	Process Control	Project Management
Process	A natural and progressively continuing operation or development marker by a series of gradual changes that succeed one another in a fixed way and lead toward a particular result.	A step-by-step set of activities needed to produce the project’s outcome. Usually performed in a linear manner in traditional methods and incrementally and iteratively in agile methods.
Systems	A combination of components that act together and perform a certain objective.	Project and product systems are separated in traditional and agile methods.
Disturbance	A signal, which tends to adversely affect the value of the output of a system.	A performance outcome that does not meet expectations. Either cost, schedule, or technical performance shortfall
Feedback control	An operation in the presence of disturbances tends to reduce the difference between the output of a system and the reference input.	Project management feedback of cost, schedule, and technical performance in mature approaches. Usually only cost and schedule is less mature.
Damping	Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations.	The control points designed to prevent *chasing our tail* when project deliverables do not meet expectations and *hot fixes* are applied creating more oscillations in the process flow

	Process Control	Project Management
Feedback control system	A system designed to maintain a prescribed relationship between the output and the reference input by comparing these and using the difference as a means of control.	Planned versus actual measures on a time basis is core to feedback. This performance must be Effectiveness, Performance, Risk, and *…ilities*
Closed loop Control	Is one in which the output signal has direct impact on the control action, as shown in **Figure 5.** In a Closed-Loop system the error signal, which is the difference between the input and the feedback, is fed to the controller to reduce the error and bring the output of the system to a desired value.	With measures of planned versus actual, corrective actions can be made. Closed-loop assures a system performs within control limits by direct feedback of system's output to change the system's inputs.
Open loop Control	Is one in which the output signal has no direct impact on the control action, as shown in **Figure 5**. In an open loop system the output is neither measured nor fed back for comparison with the input. For each reference input there is a fixed operating condition.	Planned performance and actual performance data assessed on a specific date to determine the variance from plan. With this information, corrective actions can be taken to return the project to its planned performance.
Adaptive control system	Method of control used to adapt to a controlled system where parameters vary or are initially uncertain.	For projects, information that emerges from the execution of the project is used to change to control parameters.
Performance index	Is a quantitative measure of the performance, measuring the deviation from the ideal performance? The specification of the control signal over the operating time is the ***Control Law***.	Cost, schedule, and technical performance measures used to assess performance to plan by compared planned to actual performance.
Learning control systems	Many open-loop control systems can be converted to closed-loop control system if a human operator is placed in the loop. This operator compares inputs with outputs and makes corrective actions based on the resulting errors.	Project management should be closed-loop, but statistical processes usually not included in the control loop like those found in Learning Control Systems

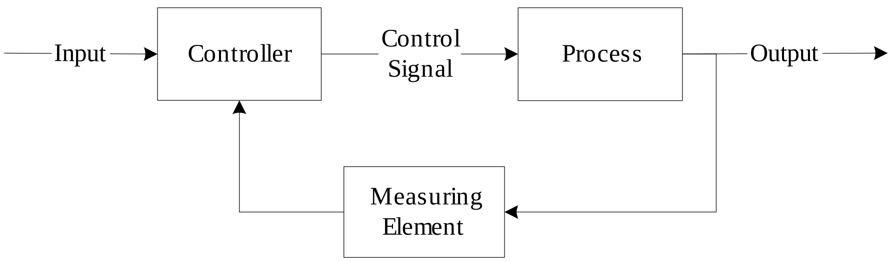
Figure 4 - Attributes of Control and Project Management Systems. Not all attributes in control systems can be found in traditional project management systems. Moving project management to be more like close-loop adaptive control systems.

Figure 5 illustrates Open Loop and Closed-Loop control systems. Only the Close Loop Control system applies to managing projects. Project management is a Closed Loop control system. Some production processes can be Open Loop control as a monitoring and reporting process.

The Open Loop control process has little value for project management but is the basis of the Close Loop control process needed to make corrective actions in the presence of *variances* in project performance.



Open Loop System



Closed Loop System

Figure 5 - Open and Closed Loop Systems. Both can be found in the project management domain. But only the Close Loop control system can provide indicators of performance variances needed to take corrective actions to maintain the needed activities to arrive on or before the need date, at or below the planned cost, and with the needed capabilities.

General Requirements for a Control System

Any useful control system must satisfy the following conditions:

The first requirement of any control system is stability.

In addition to absolute stability, the control system must have relative stability, that is the speed of response must be fast and must show reasonable damping.

A control system must be capable of reducing errors to zero or to some small tolerance level.

The requirement for relative stability and steady-state accuracy are incompatible. The design of a control system becomes a tradeoff between these two requirements.

Adaptive Control Systems

Adaptation implies the ability to self-adjust or self-modify with unpredictable changes in conditions of environment or structure. In an adaptive control system, the dynamic characteristics must be identified at all times so that the controller parameters can be adjusted in order to maintain optimal performance.

Basic Approach to Control Systems Design

One approach to the design of control systems, which will be helpful here, is to use *block diagrams*, which are pictorial representations of the functions performed by each component of the system and the *signals* that flow between these components. [10] **Figure 6** is a logical depiction of a Closed-Loop control system.

This system consists of two elements:

Block element - is the symbol of the operation performed on the input signal to produce the output signal. The notation inside the block is usually the transfer function of the block given as the Laplace function.

Error detector - produces an error signal $E(s)$, which is the difference between the reference input $R(s)$ and the feedback signal $C(s)$. The choice of the error signal is very important. Any imperfections in the error signal will be reflected in the entire system's performance.

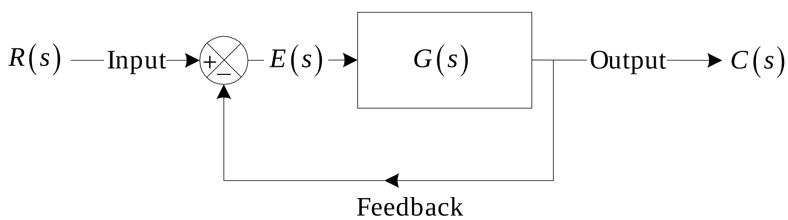


Figure 6 - A Logical Depiction of a Closed Loop Control System. This paradigm can be applied to project management systems. The error signal is the difference between *planned performance* and *actual performance.* The system under control is the baselined IMS and it's PV.

Adaptive Controls Design

Adaptive control is a specific type of control where the process is controlled in a closed loop and when: knowledge about the system characteristics is obtained online while the system 'is operating. Based upon refreshed information obtained during normal operation, specific interventions in the control loop arc are made to fulfill the control goal. Interventions can be various, but they can be categorized as interventions obtained by changing: the signals, parameters, and structure.

[10] The specific notation used in **Figure 6** will be ignored since the interest is in applying control systems theory to project management. The "functions" $E(s)$ $C(s)$ represent the reference, error, and control signals. These are functions of Laplace space rather than of time. For those not familiar with the Laplace transform, it is defined as $\mathcal{L}[f(t)] = F(s) = \int_0^\infty e^{-st}dt[f(t)] = \int_0^\infty f(t)e^{-st}dt$. Transforming a time-varying function to Laplace space can be manipulated as an algebraic expression rather than a differential equation.

In most feedback systems, small deviations in parameter values from their design values will not cause any problem in the system's normal operations, provided these parameters are inside the loop. The control system will exhibit unsatisfactory behaviors if the process parameters vary widely because of environmental changes. In some cases, large variations in process parameters will cause instability in non-adaptive systems.

A simple definition of an adaptive control system is: A control system in which continuous and automatic measurements of the dynamic characteristics of the process are taken, comparisons are made with the desired dynamic characteristics, and differences used to adjust the system parameters - usually the controller characteristics - or the generation of an actuating signal to maintain optimal system performance, regardless of the environmental changes to the process.

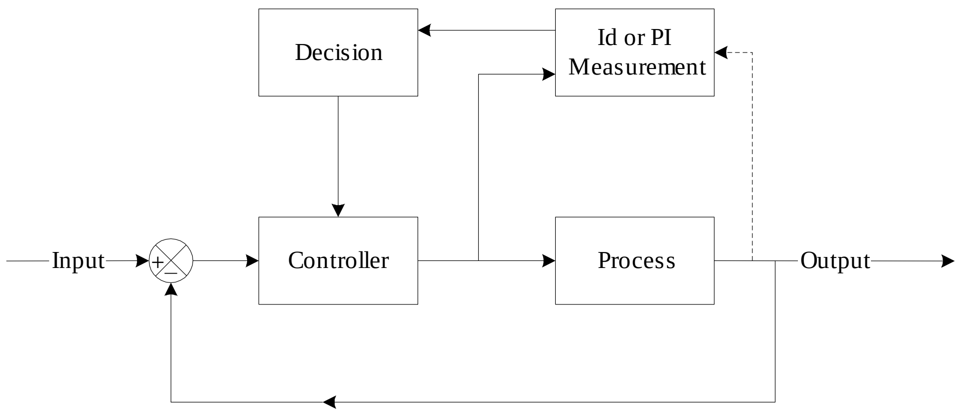


Figure 7 - Adaptive Controller makes use of measurements and feedback adjustments from the behaviors of the system in the presence of those measurements to *adapt* the control loop to the emergent behavior of the system under control.

To be called adaptive, some form of self-organizing features must exist. An adaptive controller consists of the following three functions:

Identification of the dynamic characteristics of the process.

Decision making based on the identification of the process.

Modification or actuation based on the decisions made.

By performing these functions continuously, self-organization can take place to compensate for unpredictable changes in the process.

System Behavior Identification

The dynamic characteristics of the process must be measured and identified continuously. These measures should be accomplished through the effects produced by the system's normal operation. Identification may be made from normal operating data or by injecting test signals.

Identification with normal data is possible only when this data has good signal characteristics (bandwidth, amplitude, etc.) for proper identification.

Decision Making in The Presence of Emergent Behaviors

Decisions are made based on the process characteristics with an identified or computed performance index. Once the process has been identified, it is compared with the optimal characteristics (or optimal performance). A decision is made as to how the adjustable controller characteristics should be varied to maintain optimal performance.

Modification Based on Decisions Made

Modification refers to the changes of control signals according to the results of the identification and decision processes. There are two approaches to modifying controls signals:

Controller parameter modification - in which the controller parameters are adjusted to compensate for changes in the process dynamics.

Control signal synthesis - in which optimal control signals are synthesized based on the process's transfer function, performance index, and desired transient response.

Project Management Theory as Control System Theory

With the control system theory established, let's connect that theory with the needs of software project management. This paper proposes that the characteristics of software development projects, especially agile software development, can be modeled using adaptive control system theory.

Control Theory Summary

Control is guiding a set of variables toward a common goal. *Management Control Theory* may be seen as *after-the-fact* control or *before-the-fact* control. Control theory suggests that after-the-fact rules are more effective when consequences are easily monitored. Where products are unique and hard to monitor, before-the-fact management is appropriate.

Agile Project Management and Adaptive Control

Now, we need some way to tie adaptive control theory to agile project management is required. A simple approach is to compare the primary attributes of adaptive control with agile PM methods.

Adaptive Control	Agile Project Management
Identification of the desired loop performance.	What is the project performance needed to arrive on time, on budget, with the needed capabilities?

Adaptive Control	Agile Project Management
Decision Making	By assessing the planned outcomes against with actual outcomes, decisions can be made about the corrective actions needed to maintain the planned performance.
Modification based on the decision made	With this assessment information, changes to the work processes, work intact, technical processes, and resources can be made to maintain the planned performance.

A Framework for Adaptive Project Management Processes

> Traditional project management assumes linear feedback loops, stability in the work process, and no disruptive changes to requirements. Software development projects rarely possess these attributes.

Are the methods described in traditional PM frameworks appropriate for Adaptive or Agile Project Management? One place to look for traditional frameworks is the Project Management Institute's Project Management Body of Knowledge®.

First, look at the control block picture of the PMBOK's functions. **Figure 8** describes a *simple* view of PMBOK's control elements.

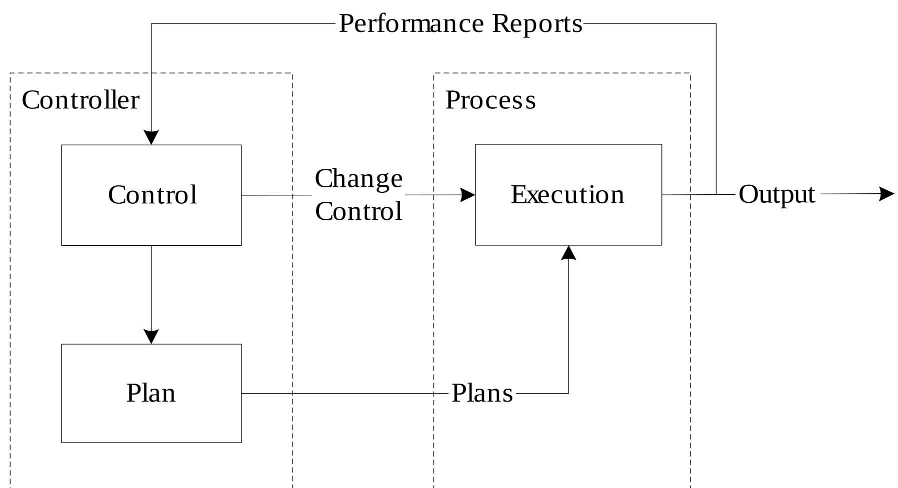


Figure 8 - PMBOK Control Blocks. There is one feedback loop and two inputs to the process under control. In PMBOK, the method is based on a Plan, and changes to the Plan are incorporated into the Plan.

Gaps In Traditional Project Management

In **Figure 8,** several things must be added to a control systems process.

There is no capacity for a work reference signal - the control flow uses performance reports to define the change control signal. These performance reports have no reference signal, which creates an "error" signal. The planned outcomes are baselined, and the actual value is compared to produce an error signal. But the planned values are not assessed for the needed capabilities and the actual capabilities of the actual values. It is not sufficient to *desire* a performance measure. These *desired* performance measures must be achievable. This missing assessment - our actual capacity for work, the achievable work - is not part of traditional project management. For project management to be successful, the work capacity must be part of the adaptive control loop.

There are multiple control signals - both plans and change control are used as a control signals. Measuring variance from the plan-set point minus measured value and changes to the set point are part of the multiple control signals. The coupling between these two control signals masks the individual contributions to the control loop. Separating these signals is needed to isolate the corrective actions in the control loop.

The dynamics and transfer functions of each process are not specified. This includes the sample rate and the response rate of each method. The traditional management process does not define the dynamics of the systems under control and the loop gained for controlling this system.

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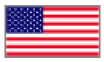

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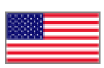

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