Applying an Integrated Systems Approach to Managing Technical Project Schedules

David S. Greenburg PhD, CPL, PMP & James K. Plemmons PhD, PE, PMP
The CITADEL/The CITADEL

Abstract

Technical projects require greater effort for effective problem solving. The lack of adequate planning and control in projects is linked to a wide gap between project management practice and applying a systems approach to project scheduling. This article looks at the key difficulties faced by engineers in managing technical project schedules and identifies the current gap in knowledge training. Project decision making can be strengthened by applying an integrated systems view. A framework is presented for developing and integrating knowledge sharing to optimize the decision process by incorporating learning effects to make better schedule management decisions. Applying an integrated systems approach when evaluating potential scheduled changes can reveal interdependencies and problem areas that are neither obvious nor well defined by other planning methods. The output will help managers determine what changes should be made for a project to stay on schedule and the downstream impact of those changes.

Keywords

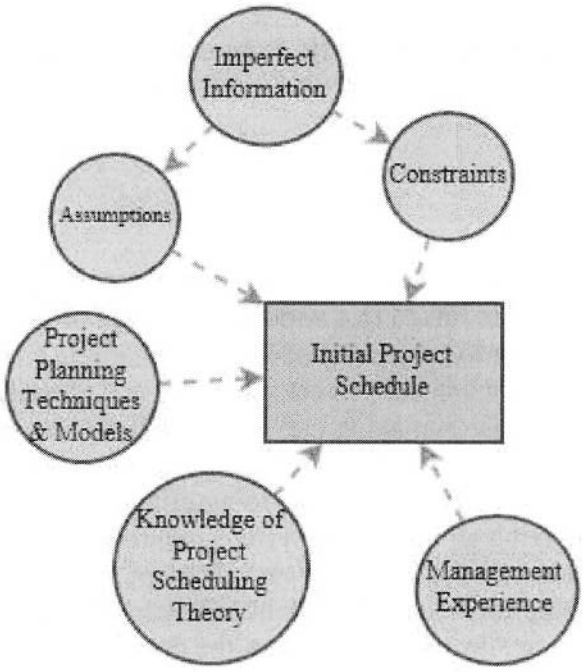
Systems approach, decision-making, schedule, technical project management.

Factors that Affect the Development of Accurate Project Schedules

Project managers are expected to play a key role in planning, developing and managing projects according to a schedule, within a budget, and while meeting required performance and profit goals. Managing a project is a complex task that requires engineers leading technical projects to be prepared to address both predictable and unforeseen problems that arise during project execution and make sound decisions.[1, 2] Projects are challenging to plan and manage because project conditions and performance evolve over time. Lyneis and Ford describe how projects rarely go as planned and when problems occur, management must be able to respond. [3]

Typically, a large portion of project management decisions center around the schedule. When it appears that schedule performance will not meet objectives, managers must be prepared to collect and evaluate information, identify and assess potential courses of actions, and then make decisions to bring the project back on schedule. While there are a number of factors that can contribute to poor project cost and performance, Siqueira found that inconsistent and unreliable schedule estimates introduce unstable assumptions and constraints into the planning process that affect future project performance. [4] Projects with overly ambitious deadlines and too few resources can result in increasing error rates, overworked employees, and declining performance.[5] Figure 1 identifies the decision model framework inputs that should be considered when developing the initial project schedule.

Figure 1. Decision Input Model for Initial Schedule Development



An important impact of using imperfect information in the schedule development phase is the downstream discovery of problems. These problems require additional management resources and cost expenditures to address. Yu describes how complex projects add uncertainty and require greater effort, information and knowledge sharing for effective problem solving. [6] Vanhoucke, Vereecke, and Gemmel emphasize the benefits that can be achieved by employing decision support tools to help engineering managers address the complexities of project planning and decision making.[7]

Grey suggests that decision models are needed that can capture and build on the manager's experience and adapt to dynamically changing program events. [8] Kerzner discusses the importance of employing a systematic, flexible, and disciplined approach to project planning. [9] Williams describes how project complexity magnifies risk and how standard methodologies evaluate risk individually and fail to account for the fact that "the risks that cause project runaway are not individual, separate risks, but rather combinations of risks in causal chains." [10] He emphasizes that project understanding can be strengthened from examining the systemic nature of projects. Engineering managers are often placed in situations requiring rapid decision making with less than perfect information and with much less certainty of the total impact of these decisions on project schedules. Many engineering managers will agree that the skills and insights used to create project schedules are not necessarily the same ones needed to subsequently manage project schedules and performance.

This paper examines the difficulties of making project scheduling decisions and identifies applicable gaps in knowledge and training that affect decision making. Using a constructive analytic approach, this paper presents research findings which are important to engineers managing technical projects. These findings are important because (1) it brings to light and

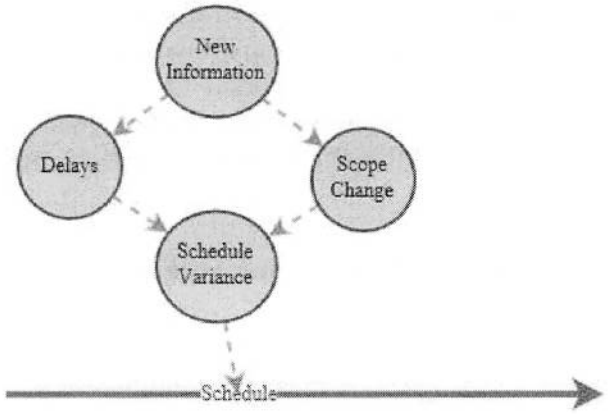
discusses the inherent difficulties of developing accurate project schedules, (2) it identifies several key variables which make it difficult for engineering managers to effectively manage the project schedule, and (3) it identifies a framework to help project managers make better decisions impacting the project schedule. This proposed framework uses a systems approach for improved decision-making. It does this by integrating knowledge sharing, scenarios, learning effects, and the development of improved mental models for the engineering project manager. In this paper the initial project schedule is developed using the proposed framework model. The model is presented in three main parts within the applicable sections before the composite model is presented in the final section.

Factors Negatively Affecting Schedule Quality and Accuracy

Engineering project managers are expected to develop and maintain an accurate project schedule, keeping it updated on a regular basis. This is typically accomplished using observed progress and judgment to ensure that the schedule accurately reflects the project plan and will support the achievement of the project goals, objectives and cost requirements. Han, O'Connor, and Choi described a quality schedule as "one that is in line with related contracts, thoroughly covers the scope of the work, clearly describes how projects will be performed." [11] Doloi emphasized the importance of maintaining an accurate project schedule and found that unforeseen conditions, low speed of decision-making and client-initiated changes are significant causes of cost overruns and that understanding the potential impacts of these factors is the key for achieving success in cost performance. [12] Research by Adoko, Mazzuchi, and Sarkani revealed that a schedule is a key indicator of whether a project will experience cost overruns or not. [13]

Projects consist of a collection of tasks that are performed in parallel and in series. An important factor affecting schedule accuracy occurs when the correlation between tasks are overlooked or underestimated. In the construction industry, Yang observed the practice of independently scheduling tasks even though the same resources, such as labor crews and equipment, are used to perform multiple tasks on the schedule. He observes that the tasks are treated as uncorrelated events when in fact they are correlated and subject to the same resource productivity and capacity constraints. [14] Parallelization of activities introduces risk by assuming that a specific event can occur in parallel with a second event that would normally be in sequence with it. During scheduling activities, it is important for project managers to be aware of precedence relationships between sequential tasks and to understand how parallel implementation may overlap and affect schedule. Tasks with no precedence relationship can often be implemented in parallel with little impact. Experience shows that for correlated tasks performed in parallel, the duration of one task tends to affect others as well. In such cases the capacities of these independently scheduled resources can easily be exceeded, resulting in schedule delays. Figure 2 identifies the decision model framework inputs that affect schedule execution and drive the need for schedule change.

Figure 2. Decision Input Model for Schedule Variance, Information, and Delay



Yang discusses how commonly used planning techniques, such as PERT, consistently lead to underestimation of expected project durations. [15] Several other authors discuss the drawbacks of traditional project management models, involving a static versus a dynamic treatment of processes, resources, targets and scope. [16, 17, 18] Due to the extent of planning related issues the intent of this paper is not to be exhaustive, but to identify several key factors that make it difficult to develop and manage project schedules. Knowledge of these key factors, along with the proposed framework for actions can be used by engineering managers to improve decision-making and project schedule management performance. Table 1 Summary of the reasons for poor schedule control and recommended actions needed to improve schedule performance.

Table 1. Summary of the reasons for poor schedule control and recommended actions needed to improve schedule performance

Reasons for poor project schedule accuracy	What is Needed
• A wide gap between project management practice and the knowledge of project scheduling theory • A lack of decision support systems or their effective employment • Methodologies evaluate risk individually and fail to account for combinations of risks in causal chains • The need for rapid decisions with less than perfect information about the causal factors • Individual estimating experience and practices that may result in the creation of unreliable schedule estimates • The failure of project management methods to adequately incorporate the effects of feedback • Initial project schedules are built with incomplete or inaccurate information • Unforeseen conditions, low speed of decision-making and client-initiated changes • Correlation between tasks are overlooked or underestimated • Traditional project management models provide a static treatment of processes, resources, targets and scope • Traditional project management models provide a static treatment of processes, resources, targets and scope • Commonly used planning techniques underestimate expected project durations • Under stress managers try to apply existing knowledge and experience subconsciously ignore available information • Actions have unintended side effects	• Practitioners are prepared to address both predictable and unforeseen problems that arise during project execution and make sound decisions • Models that can capture and build on the manager's experience • Greater effort, information and knowledge sharing • Systematic, flexible, and disciplined approach to project planning • Updated and accurate project schedules • Methodology for examining the potential impacts of decisions • Examination of precedence relationships between tasks to determine correlation • Scenario based training to exercise and improve decision making. • A conscience look for available information before jumping to conclusions • A move away from looking at isolated events and their cause and moving to a view of the system and its interacting parts. • Methods to help project managers gain confidence and sharpen the decision-making skills • Models must include iterative flows of work, and address the causal relations present in the project

Knowledge Development

Herroelen finds that the lack of adequate planning and control in projects is linked to a wide gap between project management practice and the knowledge of project scheduling theory. [19] A lack of decision support systems or their effective employment by project managers are also key causes of poor performance on projects. Jalili and Ford discuss the dynamic nature of projects and the failure of traditional project management methods to adequately incorporate feedback and create learning once a project has begun. [20] They go on to discuss the positive impact that collecting and acting on feedback can have on project knowledge and schedule performance.

Research by Lyneis and Ford reveals that when projects experience change there is an immediate need to reassess whether the schedule should be readjusted. [21] Rodrigues and Williams found that when faced with schedule slippage, management decisions usually focus on adjusting the schedule, increasing the work rate, or some combination of both. [22] Unfortunately, actions taken to adjust schedules can have unintended side effects for rework and productivity. This is especially true if the actions and their impacts were not thoroughly examined from a systems perspective.

Decision making in this fluid environment is a difficult task. However, it can be made simpler by collecting information and building project knowledge that will facilitate development of mental models that can be applied by the engineering project manager to aid decision-making. Mental models can be employed to help assess the impact of potential actions and determine the resultant effects in terms of cost, schedule, and performance on the system. Mental models are developed from imagination, perception, knowledge, and experience. Building a project knowledge base enables the development of mental models that help engineering managers interpret and understand the relationship between contemplated actions. By taking a systems approach to decision-making, managers can upgrade and improve their mental models by exercising their decision-making skills that incorporate knowledge feedback loops.

Mental models can facilitate predictive as well as diagnostic decision-making. In a predictive capacity, they are used to estimate the project outcome based on a specific action and to help identify better alternatives. In a diagnostic capacity, they are familiar with the processes to identify possible causes for observed deviations and to help understand the effects of change decisions on the project schedule. Herroelen discusses how project modeling can provide answers to such questions as “how time delays in certain elements influence project completion, where slack exists between elements, and what elements are crucial to meet the completion date.” He concludes that models provide management with a means for evaluating alternatives, reveal interdependencies and facilitate "what if" analysis to support decision-making. [22] For projects, modelling the effects of schedule changes can provide managers with valuable understanding and insight based on a specified starting point and then developing a structured route to improvement through well thought out decisions. The value of the exercise comes from assessing current capability, diagnosing strengths and weaknesses, and identifying gaps where improvement is required.

How an Integrated Systems Approach Can Help

Hillson describes the value of a formal and structured approach to project management that can be achieved through proactive management. [23] Using a systems approach to decision-making can help engineers assigned to lead projects gain confidence through practice and sharpen the decision skills needed to effectively develop and manage complex project schedules. Herroelen discusses the use of modelling in project management training and education to demonstrate how investigation of projects can improve managerial understanding, decision-making, and performance. [24] Kirkwood holds that employing a systems based approach will provide a better understanding of problems by moving away from looking at isolated events and their cause and moving to a view of the system and its interacting parts. [25]

Research supports the need for different management approaches to address the uncertainty encountered by projects. Bergman, Viljainen, Kassi, Partanen, and Laaksonen describe the use of scenario planning as a tool to provide a structured approach to decision making. [26] Scenarios are a useful way to share knowledge and build a holistic understanding of decision actions. The goal being to identify the important aspects of a particular decision and organize the possible outcomes around those goals. This approach enhances learning and identifies information decision gaps in present assumptions and provides new insight and knowledge into the decision action being evaluated by promoting a focused assessment of potential outcomes.

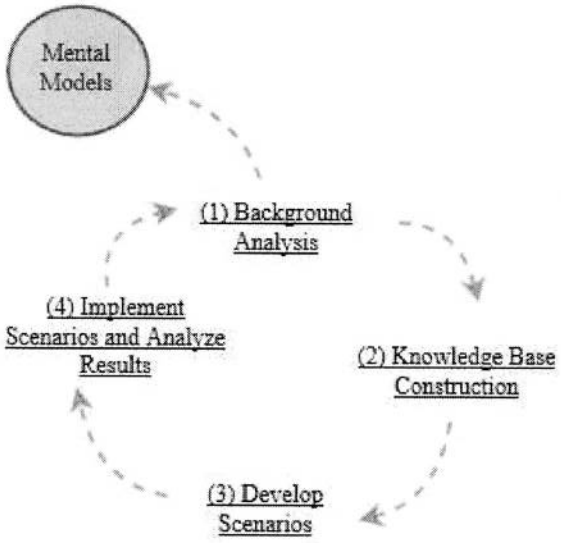
Scenario planning provides a framework to help engineering managers understand the forces impacting on project decisions, rather than solely depending on forecasts based on assumptions and judgements made with imperfect information. The value of scenario planning lies in its ability to stimulate decision makers to create new knowledge of potential actions and to gauge the interactions between decision variables that are easier to grasp. Importantly, the use of scenarios in decision-making challenges managers' current knowledge and their prevailing mindsets.

Gary, Kunc, Morecroft, and Rockart discuss research on executive decision-making and the role that mental models play, highlighting research showing that higher mental model accuracy leads to more effective decision rules regarding analogous problems. [27] By integrating scenarios into the decision process, project managers are put in a position to receive a wide variety of information relating to a specific action, interpret and assess that information. They can then apply the new knowledge gained to make an effective decision regarding that action, developing and improving mental models along the way.

Scenarios are an important component of this proposed systems framework because they facilitate the identification and evaluation of workable solutions by creating new knowledge and building greater understanding of the problem and alternative outcomes. By adapting the methods described by Bergman et al. a four-step scenario process Can be outlined. [28] Step 1. A background analysis of the problem starts by identifying the known aspects of a proposed action and any knowledge gaps, and identifying the problem scope and decision goals. Step 2. The knowledge base is constructed by taking the tacit knowledge gained from Step 1 and transforming it into explicit knowledge represented as initial scenarios created to explore decision significance and implications. Step 3. The scenarios are developed and implemented.

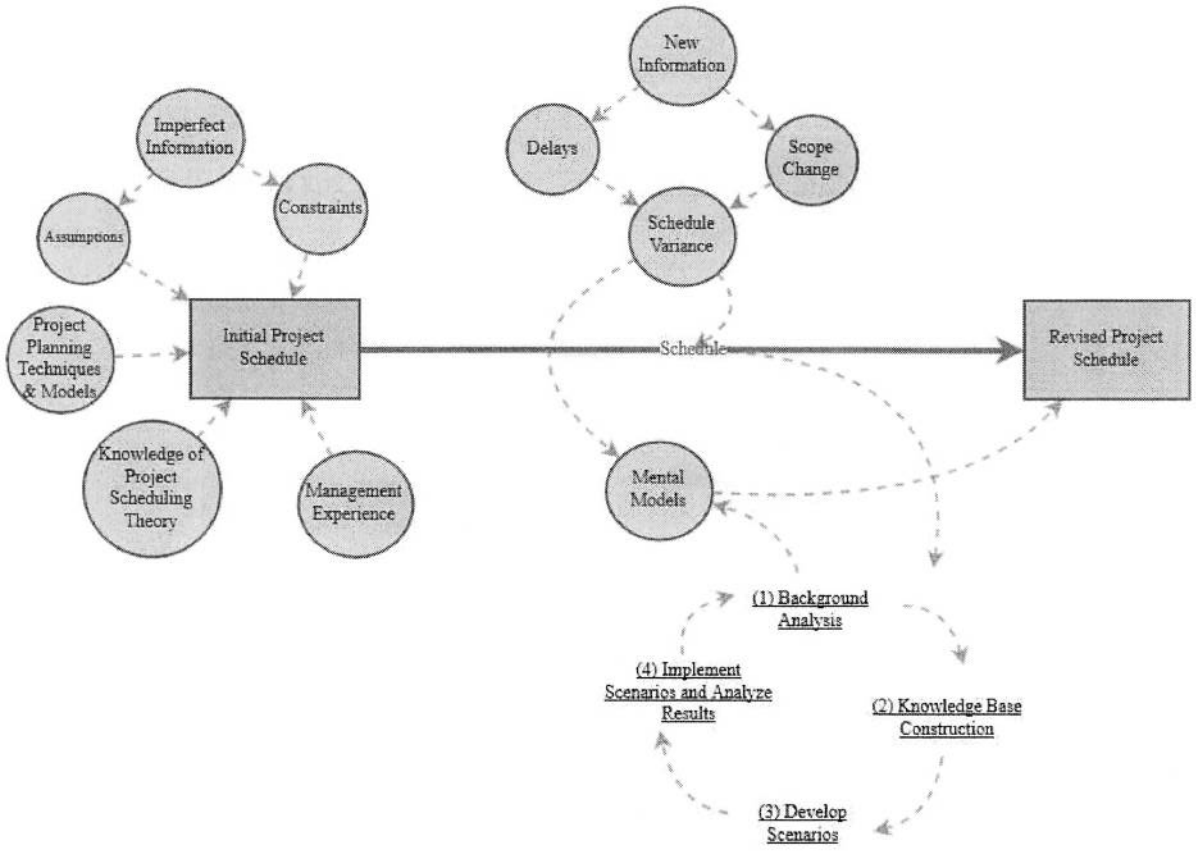
Step 4. Scenario output data is collected, analyzed and input into the decision cycle. Figure 3 identifies the decision inputs for mental model development.

Figure 3. Mental Model Development



Applying a systems approach to decision-making allows engineering managers to move away from making decisions to deal with individual events and their causes. It allows them to look at decisions as a way to improve a system of interrelated parts. The model displayed in Figure 4 incorporates the complexities of schedule development, schedule execution and variance, delay, and mental model development discussed in this paper, into one integrated systems model. This model identifies the underlying structures that cause decisions to be made and highlights the complexities involved in decision-making. The hope is that the proposed framework improves existing decision-making that is being managed intuitively, and offer a relatively simple, straightforward modeling approach which can educate and improve decision-making. One of the key differences between managers who are successful and those who are not is their ability to effectively address changes and make informed and effective decisions.

Figure 4. The Systems Based Decision Process



Discussion and Conclusion

This paper suggests a framework for applying a systems approach to decision-making that can provide important information to project managers by revealing interdependencies and problem areas that are neither obvious nor well defined by other planning methods. The proposed framework makes it possible to integrate and analyze new knowledge to help project managers determine where the greatest effort should be made for a project to stay on schedule. By employing a systems approach to decision-making managers can take a broader perspective and investigate the effects of implemented changes and the "downstream" effects of these decisions. To develop mental and organizational models for decision-making managers, need tools and processes for gathering information and processing knowledge for sharing that will enable them to proactively manage in a changing environment. As a primary interest this paper highlighted the need for the development and use of an integrated systems based approach to help project managers sharpen their decision-making abilities and assess the impacts of various changes to a program schedule. This proposed integrated approach serves to educate and provide structure to managers, while enabling improvement of their analytical and decision-making skills through standardized practice.

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David S. Greenburg, PhD, CPL, PMP

Dr. Greenburg is an Associate Professor in the Department of Engineering Leadership and Program Management (ELPM) in the School of Engineering (SOE) at The Citadel. He served over 20 years of active military service in the United States Marine Corps in a variety of command and staff and leadership positions. Upon completion of active military service, he held executive leadership positions in industry until he joined the faculty at the Citadel. His research interests include modeling project networks, technical decision making and leadership. He is a certified Project Management Professional (PMP).

James "Keith" Plemmons, PhD, PE, PMP

Dr. Plemmons is an Associate Professor in The Citadel's Department of Engineering Leadership and Program Management (ELPM) in the School of Engineering. His credentials include a PhD and MS in Civil Engineering (Construction Management) from Clemson University, a BS in Civil Engineering from The Citadel, and a certified Project Management Professional from Project Management Institute (PMI). His areas of research include 1) impact of the internet of things (IoT) on project management, construction, and supply chains; and 2) enterprise digital transformation.