LIFE CYCLE MODELS FOR HIGH-TECHNOLOGY PROJECTS
– APPLYING SYSTEMS THINKING TO MANAGING PROJECTS

RUSSELL D. ARCHIBALD, PMP, FELLOW PMI and APM/IPMA, MSc

4th International Project Management Seminar – PMI-SP Chapter
December 9-10, 2004 São Paulo, Brazil

ABSTRACT

Projects are the common denominator for all of our project management principles and practices. We must recognize that 1) there are many categories of projects, and 2) what works well in planning and controlling projects in one category is not suitable for all others. This paper first presents a proposed method of categorizing all projects based on the project results and identifies those categories that are typically considered to be "high-technology" projects.

The differences in managing projects in different categories result from the differing life cycle models used in each, as well as other factors, including (among others) the underlying technologies involved, the certainty with which the project objectives can be defined, the characteristics of the project environment, and the project management maturity of the organizations and industry sectors involved in the project. This paper focuses primarily on the various life cycle models that have emerged for the identified high-technology project categories. The two basic classes of such models, predictive and adaptive, are discussed, and examples within each class are illustrated, with references given for more in-depth study.

The intention is to enhance the reader's ability to develop and continually improve the best life cycle model for the types or categories of projects that they are directly involved with. By viewing the entire project as an integrated system through application of the best life cycle model design, significant improvements in conceptualizing, planning, executing and controlling the project can be achieved.

RECOMMENDED PROJECT CATEGORIES BASED ON PROJECT RESULTS

Projects in all their various sizes, shapes, degrees of risk and complexities, and widely varying products or results, are the common denominator for all aspects of project management. However, a useful analytical framework requires that projects be systematically grouped into categories and sub-categories. In some cases a further grouping within sub-categories and types based on other characteristics will be required. Crawford et al (2004, 2002) report the results of a PMI funded research project regarding the various project classification systems in use in North America and Australia. They discuss the need for classification systems and the related issues, implications and problems, concluding that "The categorization of projects is beneficial and useful to organizations, but it needs to be practically and not theoretically oriented." I agree, and believe that the most practical approach is based first on the products of projects.

Defining Project Categories and Sub-Categories

Ten recommended basic project categories are listed in Table 1, plus an eleventh category for all others, oriented primarily to products of the projects. Projects within each of these ten specific categories (or the identified sub-categories) are believed to have very similar life cycle phases and utilize similar authorizing, planning, budgeting, scheduling, monitoring and controlling procedures and tools throughout their life cycles no matter where in the world they are located. Subcategories are identified within nine of the ten basic categories.

In most cases there will be differences—in some cases significant—between the project life cycle management process for the basic category and at least some of its subcategories. Others may wish to add subcategories where none are shown in Table 1, or to add additional subcategories to those that are listed. Additional major categories may also be required to assure that all conceivable projects of significance to the international PM community are included. It should be noted that these categories are not necessarily mutually exclusive: many projects will include aspects of two or more categories. For example, most communications systems projects include at least the adaptation of information system software. Many facilities projects also include communication systems, and vice versa. In such cases the project probably should be classified in the more dominant category, or—if justified by size, complexity, or risk—defined as two or more projects (of different categories) within a program, with each project having a different life cycle definition

Project Categories: Each having similar life cycle phases and a unique project management process	**Examples**
1. Aerospace/Defense Projects	
1.1 Defense systems	New weapon system; major system upgrade.
1.2 Space	Satellite development/launch; space station mod.
1.3 Military operations	Task force invasion
2. Business & Organization Change Projects	
2.1 Acquisition/Merger	Acquire and integrate competing company.
2.2 Management process improvement	Major improvement in project management.
2.3 New business venture	Form and launch new company.
2.4 Organization re-structuring	Consolidate divisions and downsize company.
2.5 Legal proceeding	Major litigation case.
3. Communication Systems Projects	
3.1 Network communications systems	Microwave communications network.
3.2 Switching communications systems	3rd generation wireless communication system.
4. Event Projects	
4.1 International events	2004 Summer Olympics; 2006 World Cup Match.
4.2 National events	2005 U. S. Super Bowl; 2004 Political Conventions.
5. Facilities Projects	
5.1 Facility decommissioning	Closure of nuclear power station.
5.2 Facility demolition	Demolition of high rise building.
5.3 Facility maintenance and modification	Process plant maintenance turnaround.
5.4 Facility design/procurement/construction	Conversion of plant for new products/markets.
Civil	Flood control dam; highway interchange.
Energy	New gas-fired power generation plant; pipeline.
Environmental	Chemical waste cleanup.
High rise	40 story office building.
Industrial	New manufacturing plant.
Commercial	New shopping center; office building.
Residential	New housing sub-division.
Ships	New tanker, container, or passenger ship
6. Information Systems (Software) Projects	New project management information system. (Information system hardware is considered to be in the product development category.)
7. International Development Projects	
7.1 Agriculture/rural development	**People and process intensive projects**
7.2 Education	in developing countries funded by The World Bank, regional
7.3 Health	development banks, US AID, UNIDO, other UN, and government
7.4 Nutrition	agencies; and
7.5 Population	
7.6 Small-scale enterprise	**Capital/civil works intensive projects—**
7.7 **Infrastructure:** energy (oil, gas, coal, power generation and distribution), industrial, telecommunications, transportation, urbanization, water supply and sewage, irrigation)	often somewhat different from *5. Facility Projects* as they may include, as part of the project, creating an organizational entity to operate and maintain the facility, and lending agencies impose their project life cycle and reporting requirements.
8. Media & Entertainment Projects	
8.1 Motion picture	New motion picture (film or digital).
8.2 TV segment	New TV episode.
8.2 Live play or music event	New opera premiere.
9. Product and Service Development Projects	
9.1 Information technology hardware	New desk-top computer.
9.2 Industrial product/process	New earth-moving machine.
9.3 Consumer product/process	New automobile, new food product.
9.4 Pharmaceutical product/process	New cholesterol-lowering drug.
9.5 Service (financial, other)	New life insurance/annuity offering.
10. Research and Development Projects	
10.1 Environmental	Measure changes in the ozone layer.
10.2 Industrial	How to reduce pollutant emission.
10.3 Economic development	Determine best crop for sub-Sahara Africa.
10.4 Medical	Test new treatment for breast cancer.
10.5 Scientific	Determine the possibility of life on Mars.
11. Other Categories?	

Table 1. Recommended project categories/sub-categories [Archibald 2003, Fig. 2.3, p.35].

Classifying Projects Within Categories and Sub-Categories

There is usually a wide range of projects within each project category or sub-category in large organizations. The project management process for each project category must provide the flexibility to choose the proper level of planning and control for large, complex, high-risk, 'new territory' projects compared to smaller or 'old hat' projects. It may be necessary to further classify projects within categories or sub-categories using the following, and possibly other, characteristics:

- Project Size
- Project Complexity (diversity inherent in the project objectives and scope, number of specialist skills and organizations, sources of technology and funding, others)
- External or Internal Customer
- Degree of Customer Involvement in the Project
- Levels and Types of Risk in Projects
- Major and Minor Projects
- "Mega" Projects or Programs
- "Stand-Alone" Versus "Create Supporting Infrastructure" Projects
- "Standard" Versus "Transitional" Projects.

For more detailed discussion on using these characteristics to further classify projects see Archibald 2003, pp 37-40.

LIFE CYCLE MODELS: TYPES AND PURPOSES WITHIN PROJECT CATEGORIES

A number of commonly used models, consisting of a number of phases or stages and related decision points, have been developed and are currently in use to portray project life cycles within each project category and sub-category shown in Table 1. Such models provide a major starting point for applying systems thinking to managing projects. The models within each category and/or sub-category will show considerable similarities, but in most cases there will be significant differences in the life cycle models from one category/sub-category to the next. To be sure, the simplest four-phase life cycle model (concept, definition, execution, and closeout) will be the same for all categories. But such a simple model is of little practical value in applying systems thinking to project management.

Purposes of Project Life Cycle Process Models: The purposes of designing and documenting the overall project life cycle process for each project category are to:

- Enable all persons concerned with creating, planning and executing projects to understand the process to be followed during the life of the project.
- Capture the best experience within the organization so that the life cycle process can be improved continually and duplicated on future projects.
- Enable all the project roles and responsibilities, and the project planning, estimating, scheduling, monitoring and control methods and tools, to be appropriately related to the overall project life cycle management process.

Unless a well-documented, understandable picture of the life cycle process – the model -- for each project category/sub-category exists it will be difficult to achieve the full benefits of modern, systematic project management.

Life Cycle Phases and Decision Points: There is general agreement that the four broad, generic project phases are (common alternative terms are shown in parentheses):

- Concept (initiation, identification, selection.)
- Definition (feasibility, development, demonstration, design prototype, quantification.)
- Execution (implementation, realization, production and deployment, design/construct/ commission, installation and test.)
- Closeout (termination, including post-completion evaluation.)

However, these phases are so broad and the titles so generic that they are of little value in documenting the life cycle process so that it can be widely understood, reproduced, and continually improved. What is needed is the specific definition of perhaps five to ten basic phases for each project category and sub-category, usually with several sub-phases defined within each of the basic phases.

In designing and documenting a life cycle process (or model) for a given project category there are three parameters to work with:

- The number of basic phases and the number of sub-phases within each, together with the definition of each of these.
- Which of the basic phases and sub-phases will be strictly sequential, which will overlap, and for those that overlap how much overlap can be tolerated; whether any phases are repeated; and how they are inter-related in a process flow chart (continuous flow, spiral, or other graphic shape.)
- The number and placement of decision points (approval to proceed, revise project objectives or scope, kill/terminate, put on hold , repeat a previous phase or sub-phase) in the process.

Identification of Products or Results (Deliverables) To Be Produced in Each Phase: It is desirable to identify the products or results to be produced (documents and physical products) during each of the phases and sub-phases:

- **Documents related to the *project*** include – for the subsequent phases – revised, updated, and/or elaborated statements of project objectives and scope, plans, schedules, resource and cost estimates, evaluation of risks, earned value and other cost reports, work orders, contracts, project release authorizations, and other project management documentation.
- **Documents related to the *product or results*** include specifications, drawings, descriptions, test procedures, process and other designs, product cost estimates, test and other reports, product change orders, and other documentation closely related to the products or results of the project.
- **Physical products or results** include intermediate or final mock-ups, scale or full size models, prototypes, test articles, tools and tooling, items of equipment, facilities, consumable materials and supplies, and other physical objects. In many projects the final end results will be one or more documents (including CDs, which are electronic documents) that embody a system or describe a service to be implemented, provided, or sold, but do not include physical objects. The results of an information system project may be embodied on a CD-ROM, but the system itself is usable only of course when invisibly stored in the memory of a set of computer hardware.

Defining the Decision Points: Key decision points (events or milestones) occur at the start and end of each phase or sub-phase. They may also occur within any of the life cycle phases. The decisions typically authorize the project manager and team to:

- Proceed with the remaining work in the current phase.
- Start work on the ensuing phase.
- Re-plan and re-start a phase or sub-phase already completed if satisfactory results have not been achieved.
- Revise the project objectives, plans and schedules when major changes in scope are required.
- Terminate the project if the conclusion has been reached that its objectives cannot be achieved successfully or if the risks have been determined to be too great.
- Place the project on hold pending availability of funds, new technology, or some other external event.

Documenting a Project Life Cycle Management Process: For each project category or sub-category we must document and describe the project life cycle process to:

- Select the life cycle model to use, name the phases and sub-phases, determine their inter-relationships, and identify the key decision points.
- Describe the methods, procedures, forms, documents, tools, systems, and other practices for authorizing, planning, analyzing and mitigating risks, budgeting, scheduling, monitoring, and controlling all projects within the category.
- Specify the documents and related levels of approval authority for initiating and authorizing new projects and major changes to authorized projects.
- Identify the key project roles and define their responsibilities and authority.
- Identify and describe the major deliverables to be produced in each phase and sub-phase.
- Specify the procedures for escalating the inevitable conflicts (competition for key resources, priorities between projects, and others) and unresolved issues to the appropriate level for their prompt resolution.

Specific Life Cycle Model Examples: Table 2 lists a number of various life cycle models, with references, for some of the categories and subcategories listed in Table 1, reflecting the results of an incomplete literature search. In several of the models identified in Table 2 the decision points are referred to as "gates."

Project Categories:	Life Cycle Models and References
Generic Project Models: All (or many) project categories below.	**Belanger 1998, pp 62-72:** Generic, Waterfall, Parallel-Work, Evolutionary Models. **Morris 1994, pp 245-248:** Standard, Waterfall, Cyclical, Spiral Models.
1. Aerospace/Defense Projects 1.1 Defense systems 1.2 Space 1.3 Military operations	**DOD 2000:** Defense Acquisition Model. **NASA 2002:** Process Based Mission Assurance (PMBA) Program Life Cycle, 8 phases: 1. Program Mgt, 2. Concept Development, 3. Acquisition, 4. Hardware Design, 5. Software Design, 6. Manufacturing, 7. Pre-Operations Integration and Test, 8. Operations.
2. Business & Organization Change Projects 2.1 Acquisition/Merger 2.2 Management process improvement 2.3 New business venture 2.4 Organization re-structuring 2.5 Legal proceeding	See generic models (above)
3. Communication Systems Projects 3.1 Network communications systems 3.2 Switching communications systems	See above generic models.
4. Event Projects 4.1 International events 4.2 National events	See above generic models.
5. Facilities Projects 5.1 Facility decommissioning 5.2 Facility demolition 5.3 Facility maintenance and modification 5.4 Facility design/procurement/construction	See above generic models.
6. Information Systems (Software) Projects	**Desaulniers and Anderson 2002:** Predictive (Waterfall, Prototyping, RAD, Incremental Build, Spiral) and Adaptive (ASD, XP, SCRUM) Models. **Whitten 1995, pp 19-22:** Code and Fix, Waterfall, Incremental, Iterative Model. **Muench 1994:** Spiral Software Development Model. **Lewin 2002, p 47:** "V" Software Development Model; p 50: Formula-IT Development Model. **Kezsbom & Edward 2001, p 122:** Refined Process Spiral Model.
7. International Development Projects 7.1 Agriculture/rural development 7.2 Education 7.3 Health 7.4 Nutrition 7.5 Population 7.6 Small-scale enterprise 7.7 **Infrastructure:** energy (oil, gas, coal, power generation and distribution), industrial, telecommunications, transportation, urbanization, water supply and sewage, irrigation)	**World Bank Institute 2002, Module 1.** **People and process intensive projects** in developing countries funded by The World Bank, regional development banks, US AID, UNIDO, other UN, and government agencies; and **Capital/civil works intensive projects—** often somewhat different from *5. Facility Projects* as they may include, as part of the project, creating an organizational entity to operate and maintain the facility, and lending agencies impose their project life cycle and reporting requirements.
8. Media & Entertainment Projects 8.1 Motion picture 8.2 TV segment 8.2 Live event	
9. Product and Service Development Projects 9.1 Information technology hardware 9.2 Industrial product/process 9.3 Consumer product/process 9.4 Pharmaceutical product/process 9.5 Service (financial, other)	**Cooper and Kleinschmidt 1993:** Stage-Gate ® Process Model **Kezsbom & Edward 2001, pp 108:** Stage/Gate Product Development Model. **Thamhain 2000:** Phase-Gate Process Model. **Murphy 1989:** Pharmaceutical Model.
10. Research and Development Projects 10.1 Environmental 10.2 Industrial 10.3 Economic development 10.4 Medical 10.5 Scientific	**Eskelin 2002, p 46:** Technical Acquisition: Basic Model, Phased Model, Multi-Solution Model.

Table 2. Project life cycle models and references: generic and for various project categories [Archibald 2003, pp 45-46].

The detailed project management project process for a given project category must also include provisions for handling projects of different sizes, complexities, risks, durations, sources of funding, and serving different customers.

HIGH TECHNOLOGY PROJECT CATEGORIES AND LIFE CYCLE MODELS

We focus on four basic project categories here: Of the ten recommended project categories listed in Table 1, we will focus primarily on these four main categories:

- Communications Systems Projects
  - Network communications systems
  - Switching communications systems
- Information Systems Projects
- Product and Services Development Projects
  - Information technology hardware
  - Industrial product/process
  - Consumer product/process
  - Pharmaceutical product/process
  - Service (financial. Other)
- Research and Development Projects
  - Environmental
  - Industrial
  - Economic development
  - Medical
  - Scientific

Defense/aerospace, facilities, and other categories listed in Table 1 of course may involve high technology, but for several reasons are not included here in our discussion of high-technology projects. From the American perspective, the defense category involves unique and highly developed U. S. Department of Defense procurement and development practices, and aerospace involves unique and highly developed U. S. NASA procurement and development practices. Some commercial aerospace projects may be considered to be in the new product development category. Facilities design, procurement and construction projects will frequently involve high-technology as well, but the procedures and practices in this very mature segment of the project management discipline generally override the high-technology considerations. The high-technology portion of a facilities project may be considered to be a separate sub-project within the overall facilities program or project, with its own specific life cycle model.

Two Types of High-Technology Life Cycle Models: There are two types of life cycle models as shown in Table 2 for these high-technology project categories: Predictive and Adaptive. Examples for information system development projects are given here, but may also apply to some other high-technology projects.

Predictive life cycle models "favor optimization over adaptability" (Desaulniers and Anderson 2002) and include:

- **Waterfall** (also known as traditional and top-down): linear ordering of the phases, which can be strictly sequential or overlapping to some extent; no phase is normally repeated.
- **Prototyping:** functional requirements and physical design specifications are generated simultaneously.
- **Rapid Application Development (RAD):** based on an evolving prototype that is not thrown away.
- **Incremental Build:** decomposition of a large development effort into a succession of smaller components.
- **Spiral:** repetition of the same set of life-cycle phases such as plan, develop, build, and evaluate until development is complete.

Adaptive life cycle models "accept and embrace change during the development process and resist detailed planning" (Desaulniers and Anderson 2002) and include:

- **Adaptive Software Development/ASD:** Mission driven, component based, iterative cycles, time boxed cycles, risk-driven, and change-tolerant.
- **Extreme Programming/XP:** Teams of developers, managers, and users; programming done in pairs; iterative process, collective code ownership.
- **SCRUM:** Similar to above adaptive life cycle models with iterations called "sprints" that typically last 30 days with defined functionality to be achieved in each sprint; active management role throughout.

Project Environment Impact on the Life Cycle Model: Design and adaptation of the life cycle model for each project category or subcategory must reflect the important characteristics of the project environment. "The organizational characteristics, the degree of familiarity with the technology to be used, and the competitive demands for initiating the project are just some of the environmental factors that can vary from project to project" (Desaulniers and Anderson 2002.)

> **Extreme Programming Resources** February 25,2003 [quoted from www.pcmag.com]
> www.extremeprogramming.org/index.html . At this site, titled "Extreme Programming: a gentle introduction" you'll find a good explanation of FP with lots of diagreams and other resources.
> www.industriallogic.com . This is the site of Joshua Kerievsky's XP coaching and consultancy company. It's a good source of white papers, articles, and seminars on Extreme Programming.
> www.xprogramming.com . Ron Jeffries' Extreme Programming site is full of in-depth articles on XP. You'll also find book reviews, downloads, and more.
> www.objectmentor.com/home . Object Mentor is a consulting firm that helps companies transition to Extreme Programming. The site has lots of XP material and information on object oriented programming.
> http://c2.com/cg/wiki?ExtremeProgrammingRoadmap . This site was created by Ward Cunningham, codeveloper of XP, and is a great source with lots of info that drills down into individual processes and roles within the XP environment.

IMPROVING THE PROJECT LIFE CYCLE MANAGEMENT SYSTEM (PLCMS)

Once the life cycles have been designed and documented for each category or subcategory of projects [see Archibald, 2003, Chapter 2, Section 2.5, "Life Cycles for 'High-Technology' Projects,"] it is then possible to define and document the project life cycle management system for each appropriate category. Only when such documentation exists can the system be improved on a systematic basis.

To establish a total quality management (TQM) approach to an organization's project management capabilities and to avoid sub-optimal improvements being introduced on a disjointed, piece-meal basis, the following approach is recommended:

1. **Document the integrated life cycle process model:** As discussed earlier.
2. **Document and describe the resulting *Project Life Cycle Management System* (PLCMS)** for each project category within the organization: also discussed earlier.
3. **Re-engineer the integrated process** to apply appropriate re-engineering methods to each category's PLCMS to:
    a. Identify system constraints, gaps and weaknesses.
    b. Identify 'speed bumps' that inadvertently slow the process down and potential 'accelerators' that can speed it up.
    c. Relate the undesirable project results and possible causes to the PLMSC wherever possible.
    d. Redesign the PLMSC beginning with the most obvious constraints, gaps and weaknesses and document the results.
4. **Implement the Improvements.**
    a. Obtain needed agreements and conduct appropriate tests or analyses to prove out the validity and feasibility of the proposed system revisions.
    b. Plan, approve and execute the improvement project to implement the revised PLMSC.
5. **Repeat the steps as required** until an optimum achievable PLMSC has been implemented.

Improving the New Product Life Cycle Process

Cooper et al (2001, Appendix A, "Overhauling the New Product Process: Stage-Gate ™ Methods—A Synopsis", pp 333-339) describe a useful approach to improving the new product development process based on their extensive experience in a number of industries.

> "Many companies have undertaken internal audits only to conclude that their new product process isn't working. Projects take too long; key activities and tasks are missing; and Go/Kill decisions are problematic. As a result, they have overhauled their process using a Stage-Gate ™ approach [see Figure 1.] Numerous

benchmarking studies and investigations into winners versus losers have pointed to the following goals for a successful new product process:
Goal 1: Quality of Execution….
Goal 2: Sharper Focus, Better Project Prioritization….
Goal 3: A Strong Market Orientation….
Goal 4: Better Upfront Homework and Sharp, Early Product Definition….
Goal 5: A True Cross-Functional Team Approach….
Goal 6: Delivery of Products with Competitive Advantage—Differentiated Products, Unique Benefits, Superior Value for Customers….
Goal 7: A Fast-Paced and Flexible Process…"(Cooper et al 2001, pp333-336).

These authors provide complete and authoritative information on how to design, implement and improve an organization's new product life cycle process (Cooper et al 2001, Chapter 11, "Designing and Implementing the Portfolio Management Process: Some Thoughts Before You Charge In," pp 303-332).

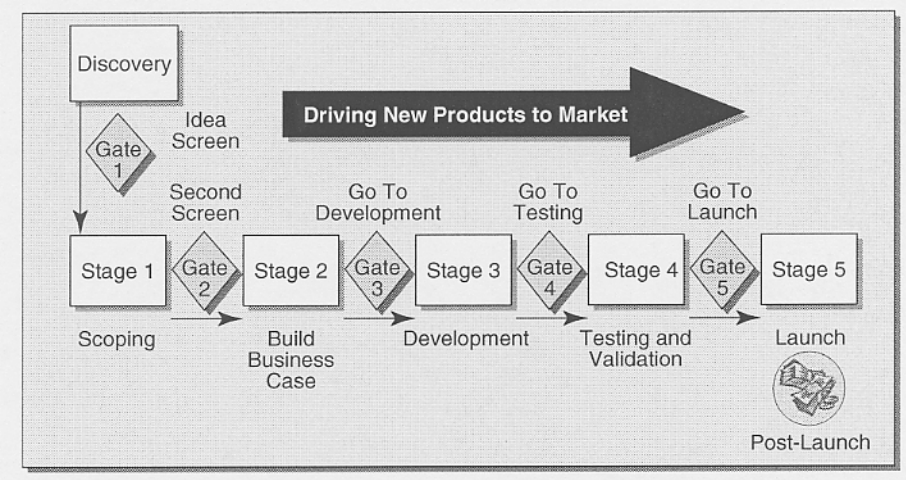
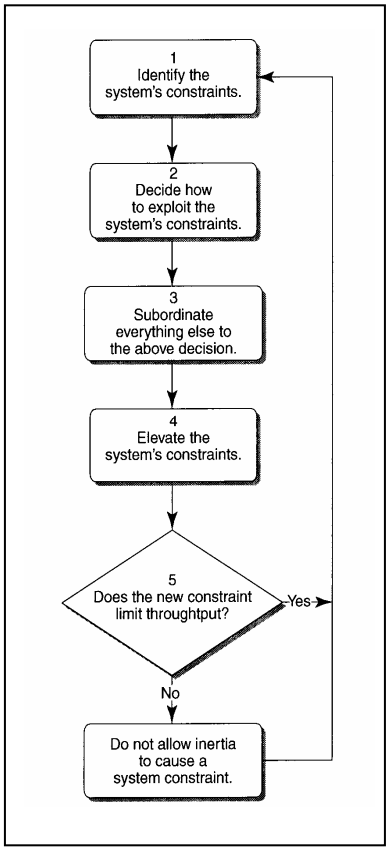


Figure 1. Overview of a typical Stage-Gate™ process. *Source:* Robert G. Cooper *et al*, *Portfolio Management for New Products* (Cambridge, MA, 2001), p. 272. www.perseuspublishing.com. Used by permission. Stage-Gate is a registered trademark of R. G. Cooper & Associates Consultant, Inc., a member company of the Product Development Institute. See www.prod-dev.com .



Consider Applying the Theory of Constraints (TOC) to Improve the PLCMS: The theory of constraints (TOC) and its application to project management, critical chain project management (CCPM) (Goldratt, 1997), have generated considerable enthusiasm among many practitioners and consultants in the past few years in the project management field.

Basically, TOC is a commonsense way to understand a system. TOC says, "Any system must have a constraint that limits its output.…The purpose of using TOC is to improve a business system. In *What Is This Thing Called Theory of Constraint, and How Should It Be Implemented?*, Goldratt (1997) stated: … before we can deal with the improvement of any section of a system, we must first define the system's global goal; and the measurements that will enable us to judge the impact of any subsystem and any local decision, on this global goal" (Leach, 2000, p 52, 53). Application of TOC to the improvement of a PLCMS is summarized in Figure 2.

The global goal of any PLCMS is to proceed from the start of the concept phase through to completion of the project execution and closeout phases as quickly as possible while consuming minimum resources (human, money, materials, and facilities). Leach (2001) provides a detailed explanation of the theory, tools and techniques for applying TOC together with the total quality management approach to improving project management systems. He also describes how TOC and critical chain project planning and control can improve schedule and cost performance on projects.

Figure 2. The five focusing steps that represent the TOC approach to on-going improvement. *Source:* Lawrence P. Leach, *Critical Chain Project Management* (Norwood, MA: Artech House, 2000), p. 62. Used by permission.

CONCLUSIONS

1. Projects must be categorized for a number of reasons; categories based on results to be produced by each project are recommended as being the most useful. Within such major categories, sub-categories are necessary. Further classification is desirable to at least distinguish between projects requiring full-blown project management and those smaller, easier projects that need only 'bare-bones' project management.
2. Project life cycle models must be designed for each project category/sub-category by defining the appropriate number of phases and sub-phases, determining how these are related, identifying the deliverables for each, and defining and relating the appropriate number of decision points between and within the phases and sub-phases.
3. The project life cycle management process/PLCMS for each project category/sub-category must be well-defined in order to enable the application of systems thinking to improve the process.
4. Two types of life cycle models are in use for high-technology projects: predictive and adaptive, reflecting the environmental factors influencing the project in question. Some examples of each type have been given and discussed briefly.
5. Application of the Theory of Constraints/TOC (or other re-engineering methods) to the PLCMS on a total system, phase, or sub-phase basis enables systematic improvement in the methods used to manage all categories and types of projects.
6. Continual, systematic improvement of the Project Life Cycle Management System must be adopted as a major goal of project management within every organization.

References

Archibald, Russell D., *Managing High-Technology Programs and Projects*, 3rd Ed. New York: Wiley. 2003.

Belanger, Thomas C., "Choosing a Project Life Cycle," *Field Guide to Project Management*, pp 61-73. David I. Cleland, Ed. New York: Wiley. 1998.

Cooper, Robert G., and Elko J. Kleinschmidt, "Stage-Gate Systems for New Product Success," *Marketing Management*. I (4), 20-29. 1993. See www.prod-dev.com .

Crawford, Lynn; J. Brian Hobbs and J. Rodney Turner, *"Project Categorization Systems and their Use in Organisations: an empirical study,"* PMI Research Conference 2004, London UK

Crawford, Lynn, J. Brian Hobbs, and J. Rodney Turner, "Matching People, Projects, Processes, and Organizations,' *Proceedings of the Project Management Institute Annual Seminars & Symposium,* Oct. 3-10, 2002. San Antonio, Texas, USA. Newtown Square, PA: Project Management Institute.

Desaulniers, Douglas H., and Robert J. and Anderson, "Matching Software Development Life Cycles to the Project Environment," *Proceedings of the Project Management Institute Annual Seminars & Symposium,* Nov. 1-10, 2001. Nashville, TN. Newtown Square, PA: Project Management Institute.

Eskelin, Allen, "Managing Technical Acquisition Project Life Cycles," *PM Network,* March 2002.

Goldratt, E. M., *Critical Chain*. Great Barrington, MA: North River Press, 1997.

Goldratt, E. M., What Is This Thing Called Theory of Constraints, and How Should It Be Implemented? Croton-on-Hudson, NY: ASQC Quality Press, 1997.

Kezsbom, Deborah S., and Katherine A. Edward, *The New Dynamic Project Management—Winning Through Competitive Advantage*. New York: Wiley-Interscience. 2001.

Leach, Lawrence P., *Critical Chain Project Management*. Norwood, MA, USA: Artech House, Inc., 2000. www.artechhouse.com .

Lewin, Marsha D., Better Software Project Management—A Primer for Success. New York: Wiley. 2002.

Morris, Peter W. G., *The Management of Projects.* London: Thomas Telford. 1994.

Muench, Dean, et al. 1994. *The Sybase Development Framework*. Oakland, CA: Sybase, Inc.

Murphy, Patrice L., "Pharmaceutical Project Management: Is It Different?," *Project Management Journal*, September 1989.

NASA 2002, "The PBMA Life Cycle and Assurance Knowledge Management System (KMS)"; www.hq.nasa.gov/tutorial/Details/implement.

Thamhain, Hans J., "Accelerating Product Developments via Phase-Gate Processes," *Proceedings of the Project Management Institute Annual Seminars & Symposium,* Sept. 7-16, 2000. Houston, TX. Newtown Square, PA: Project Management Institute.

U. S. DOD Department of Defense Instruction 5000.2 (Final Coordination Draft, April, 2000.) Washington DC: U. S. Government Printing Office.

Whitten, Neal, Managing Software Development Projects. New York: Wiley. 1995.

World Bank Institute, Knowledge Products and Outreach Division, *Managing the Implementation of Development Projects, A Resource Kit on CD-ROM for Instructors and Practitioners.* 2002. The World Bank, Room J-2-105, Washington, D.C., 20433 USA. Contact John Didier at Jdidier@worldbank.org.

Youker, Robert, "The Difference Between Different Types of Projects," *Proceedings of the PMI 1999 Seminars & Symposium* Philadelphia, PA, Oct. 10-16, 1999. Newtown, PA: Project Management Institute.