



CONSTRUCTION INDUSTRY INSTITUTE

DESIGN FOR MAINTAINABILITY:
IMPROVING PROJECT
RETURN ON INVESTMENT

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Design for Maintainability: Improving Project Return on Investment

**Prepared by
The Construction Industry Institute
Design for Maintainability Research Team**

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Executive Summary

Of the many trends that are forging their way onto the horizon of project planning, design for maintainability is one that holds great promise for improving the capital investment process. Design for maintainability, when incorporated effectively as a “best practice,” can enable less rework, smoother startups, and less costly maintenance after project completion.

The Construction Industry Institute (CII) chose design for maintainability as a topic of research because of the concern for more effective front-end planning, more efficient designs, and more prudent life cycle costs. The CII Design for Maintainability Research Team was formed to investigate the current state of maintainability practices that impact project design and construction, and to provide recommendations for improved processes that minimize life cycle costs. The results of the research team’s work are summarized in this publication.

The major contribution from the team is its CII Implementation Resource, *Design for Maintainability Guidebook*. That publication (CII IR142-2) helps the reader initially by defining the five levels of maintainability uncovered in the research. Second, the guidebook provides a self-assessment to help identify the user’s current level of maintainability. Once that is determined, the guidebook identifies not only 22 best practices, but contains 16 different tools that can assist the user in putting the best practices to work on actual projects.

Emerging trends in the Information Age often lean toward the technology end of the spectrum. Design for maintainability, however, is decidedly different. It simply requires corporate commitment and consideration as a “best practice.” Those companies that make the commitment to establish design for maintainability as a corporate best practice will be more likely to have both an improved rate of return on investment and more successful projects.

Introduction

The Case for Design for Maintainability Research

What more can be done to improve project return on investment?

Implementing design for maintainability may offer an answer to this question. Design for maintainability provides clear steps that can be taken to assist owners, designers, and contractors in exploiting additional opportunities for improving the project delivery process. The CII Design for Maintainability Research Team (RT 142) investigated design for maintainability and found that on a qualitative basis, improvements in maintainability will improve project contributions to profitability.

Historically, the typical maintenance program has been developed after systems have been chosen and installed. In effect, traditional owner-driven maintainability programs have been reactive and more costly than need be. Including a design for maintainability process in each capital project should be the first step of an effective maintenance program.

Maintainability is not a new concept, yet many companies struggle with consistent, standardized maintenance input during the project delivery process. Similarly, the research team initially struggled with understanding and defining maintainability. Developing a “landscape” of related concepts and patterning this research after the successful CII constructability research both were helpful in clarifying the research purpose and direction.

Design for maintainability, similar to constructability, emphasizes the importance of timely integration of design and construction knowledge into project designs at an early stage.

Design for maintainability follows this established procedure by integrating operation and maintenance (O&M) experiences into the project planning, design, and construction process.

Concepts

It is helpful to distinguish among the major concepts of facility operation to obtain a clearer picture of what maintainability is all about. The three major concepts are briefly explained below.

For purposes of this research, **maintainability** is considered as inherent to the system design, regarding the ease, accuracy, safety, and economy of maintenance tasks. This notion emphasizes the ability to maintain a facility while elevating its importance as a design characteristic. The purpose of maintainability is to improve effectiveness and efficiency of maintenance. In addition, the CII context of maintainability refers to a formal process to include relevant maintenance input during all phases of the facility delivery process.

For some industries, maintainability is a quantitative measure, corresponding to the probability of performing a maintenance action or repair in specified period of time using prescribed procedures in a prescribed environment. For others, maintainability is simply the ease in which maintenance actions can be performed.

Reliability pertains to the frequency of failure and the ability to function as required. Issues affecting reliability include operating practices, design, purchasing, installation, and maintenance practices.

Availability pertains to the amount of time that machinery/equipment will be operable when needed. Often referred to as uptime, availability improvements translate to increased production for manufacturing and industrial companies. Reliability is often improperly interchanged with availability. In fact, reliability is only a component of availability.

Summary

Design for maintainability is the first step of an effective maintenance program, linking maintenance goals to the design process. If adequate measures for cost-effective maintainability are not integrated into the design and construction phases of a project, the risk increases that (1) reliability will be adversely impacted and (2) total life cycle costs will increase significantly.

Appropriate levels of maintainability seldom occur by chance. Front-end planning, setting objectives, disciplined design implementation, and feedback from prior projects are all required. It is vital to identify critical maintainability and reliability issues and integrate them into facility project designs to achieve long-term facility owning and operating benefits.

Research Objectives, Scope, and Methodology

Research Objectives

The objectives of this research were to:

1. Investigate and define existing levels of maintainability implementation;
2. Identify best practices that improve the maintainability of capital projects;
3. Develop a model process for implementing maintainability; and
4. Conduct case studies to illustrate the state of practice for maintainability.

As of this writing there is insufficient data available to perform useful analyses of the economic benefits of design for maintainability.

Research Scope

The scope of this research explores delivery of maintainable equipment, systems, and facilities as it pertains to the six phases of the design and construction of capital projects delivery process. These six phases are:

1. Planning
2. Design
3. Procurement
4. Construction
5. Startup
6. Operations and Maintenance

The research surveyed a cross-section of companies engaged in many different types of construction, ranging from general building to petrochemical type projects. The organizations studied in this investigation were medium to large-sized companies (i.e., annual sales volume over \$20 million) currently involved in the design/construction industry as owners, designers, suppliers, or contractors. As maintainability most directly impacts the owners of capital projects, this research focused on owner organizations.

Research Methodology

The research methodology for this investigation consisted of the following six phases, with considerable overlap between each phase:

1. Survey of available literature
2. Interviews
3. General survey questionnaire
4. Data collection interviews
5. Case studies
6. Definition of implementation process and best practices
7. Development of *Design for Maintainability Guidebook*, IR 142-2

General Questionnaire Survey

A questionnaire survey was developed by the research team based on information gathered from the literature survey, interviews, and team member expertise.

The survey was developed to meet the following objectives:

1. Assess design for maintainability to refine the research objectives and scope.

2. Accumulate recommendations for improving maintainability.
3. Identify barriers impacting the implementation of design for maintainability.

Approximately 75 surveys were distributed, and 48 surveys were returned, a response rate of approximately 65 percent. Of these returned surveys, 46 surveys were from owners. The surveys that were returned had the following approximate distribution of performing construction in the following areas:

- 29 percent chemical
- 29 percent aerospace
- 13 percent petrochemical
- 13 percent general building
- 4 percent steel
- 12 percent other

Data Collection Interviews

Structured personal interviews were the primary means of data collection. The research team interviewed 35 organizations to investigate the current practice of implementation of maintainability within each company. Of these 35 interviews, 24 were formal interviews using the interview guide. Greater data availability and maturity of maintainability efforts further pointed the research team toward the industrial sector for investigation. Industrial and manufacturing companies appear to have a keen interest in increased maintainability, given its direct impact on profitability.