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Planning for Startup:
An Evaluation of Factors Affecting
the Startup of Process Industry Facilities

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Planning for Startup:
An Evaluation of Factors Affecting the Startup of Process Industry Facilities

by

John Stanford McLeod, B.S., M.S.

Dissertation

Presented to the Faculty of the Graduate School of
The University of Texas at Austin
in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

The University of Texas at Austin
December 2000

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Dedication

To my children Corinne and Philip for their enthusiasm and sweet reminders: *Dad are you done yet?* To Dr. Jackie Dudley for her steadfastness. To Buck Dudley a true American success story. To my dad who encouraged me to take this journey but unfortunately did not live long enough to see me finish. To Dr. Jack Matson for his many years of friendship and support. To Dr. Davis Ford for his encouragement. And finally to all the future seasoned engineers who decide to take this road -- it is worth the trip.

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I am indebted to my supervising professor, Dr. James O'Connor for his support and giving me the opportunity to learn. I would also like to thank the other members of my dissertation committee, Dr Richard L. Tucker, Dr. G. Edward Gibson, Dr. William Kelly and Dr. James Fair for their participation in this research effort.

I will be forever indebted to the wonderful faculty at the University of Texas at Austin for teaching me so much. Finally I want to thank Elaine Jones for her review and editing of the initial draft of this dissertation.

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Planning for Startup:
An Evaluation of Factors Affecting
the Startup of Process Industry Facilities

Publication No.____________

John Stanford McLeod, Ph.D.
The University of Texas at Austin, 2000

Supervisor: James T. O'Connor

This research investigated the nature and timing of startup planning for major capital projects and assessed its relationship to startup success. The major objectives were to: 1) Validate the Construction Industry Institute (CII) model - Planning for Startup; 2) Identify specific model activities that significantly contribute to startup success; and 3) Identify project management activities that contribute to model implementation. Twenty-six recently completed plant startups projects with an average cost of $220 million were analyzed.

A Startup Success Index (SSI) was developed and shown to be a reliable measure of startup success. The success of a startup was shown to be significantly related to three project variables including: 1) the level of startup planning (i.e. the level of model implementation); 2) the maturity of

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manufacturing process technology; and 3) the presence of regulatory externalities.

The research also showed that startup success is not statistically related to: 1) the total installed cost of the project and 2) the characteristics of the construction site.

The research demonstrated that, at 0.05 significance level, a startup planning effort based on the activities in the CII Planning for Startup model was positively correlated with startup success. Furthermore, the research determined that the success of a startup is significantly correlated with eighteen activities in the CII model. Conclusions from the project data are presented to assist others in implementing the CII Planning for Startup model. Areas addressed include scheduling, startup budgeting, assignment of the project manager, startup training, startup incentives and identification of startup systems.

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Chapter 1 Introduction

This research investigated the nature and timing of startup planning for major capital projects and assessed its relationship to startup success. The major objectives were to:

- Validate the Construction Industry Institute model: Planning for Startup (CII 1998).
- Identify those activities in the Planning for Startup model that significantly contribute to startup success.
- Identify other project management activities that either contribute to the implementation of the model or to the success of the startup.

1.1 MEANING AND IMPORTANCE OF STARTUP

Major capital projects in the process industry are characterized by a typical cycle of project phases. They begin with a business planning and requirements definition phase followed by; conceptual and detailed engineering, procurement, construction, startup, and commercial operation. After a sustained period of commercial operation, the project may be dismantled or reconfigured by means of another project. The interface points between phases can be gradual and there is often considerable overlap between the end of one phase and the beginning of the next.

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CII (1998) defines startup a transitional phase that occurs between construction and commercial operations. It can be as simple as opening a new highway or as complex as the initial production of electrical power at a nuclear power plant. Startups are conducted in stages and follow the general sequence listed below:

1. System Turnover (Mechanical Completion)
2. System Check-out
3. System Commissioning
4. Introduction of Feedstock
5. Performance Testing
6. Initiate Production or Commercial Operations

A successful startup is considered essential to project success because:

- Startup costs are significant. Startup costs average approximately 5.5% of construction costs (Myers et al 1986).
- Startup failure is expensive. A delayed startup costs between 4% and 8% of the fixed capital cost per month of delay (King 1977).
- Startup is risk-intensive. Risks range from contractual risks due to delays in product delivery to human health and environmental risks.
- Startup is not a one-time event. It occurs numerous times over the life of a facility when you consider the initial startup, revamp projects, de-bottlenecking activities, and maintenance turnarounds. Because startup is an integral part of a facility's operating life, plans from a successful initial startup can be utilized and improved upon in subsequent startups.

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- Startup is memorable. The startup phase is typically the last phase where both the construction manager and constructor are involved: Therefore, a successful startup often leaves a lasting positive impression with the owner.

The importance of a successful startup is evident, given the challenging characteristics of today's industrial business environment:

- Pressures to increase profits by reducing costs
- Reduction in owner project staff and increases in outsourcing of services
- Demand for shorter project cycle times

Planning for startup is difficult due to: the extensive coordination and input needed early in the project; the lack of planning capabilities and supportive tools; and the perception that startup is sufficiently far into the future that adequate planning time will be available later.

A successful startup requires not only that many disciplines work together, but also that these disciplines view the project from a systems perspective. The process of shifting the project team from a discipline-based construction paradigm to a systems-based startup paradigm is not easy. Furthermore, since the early phases of the project have the greatest impact on project success, it is critical that startup planning occurs earlier in the project cycle.

1.2 BACKGROUND OF THE CII PLANNING FOR STARTUP MODEL

CII was founded in the early 1980's to improve the cost effectiveness of the construction industry through industry-wide cooperative research. In recent

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years, CII has focused its research efforts on improving project performance through increased planning early in the project's life cycle. The CII has conducted much research into the effects of incorporating construction planning early in a project and has identified a need for better up front planning for startup.

In the spring of 1995 the CII's Research Team 121 (RT 121, the Planning for Startup Research Team) was formed to identify problems with traditional startup planning and to develop methods and tools to help industry plan startup in a more thorough, effective and efficient manner. The research team completed its work and prepared a best-practice management model for planning successful startups. This model, the Planning for Startup (PFS) model, consists of 45 planning activities organized into the following eight project phases.

- Phase 1 - Requirements Definition and Technology Transfer
- Phase 2 - Conceptual Development and Feasibility
- Phase 3 - Front-End Engineering
- Phase 4 - Detailed Design
- Phase 5 - Procurement
- Phase 6 - Construction
- Phase 7 - Checkout and Commissioning
- Phase 8 - Initial Operations

Figure 1.1 shows how these activities are distributed among the 8 project phases. Over 50% of the activities are within the three phases; Front-End, Design and Construction.

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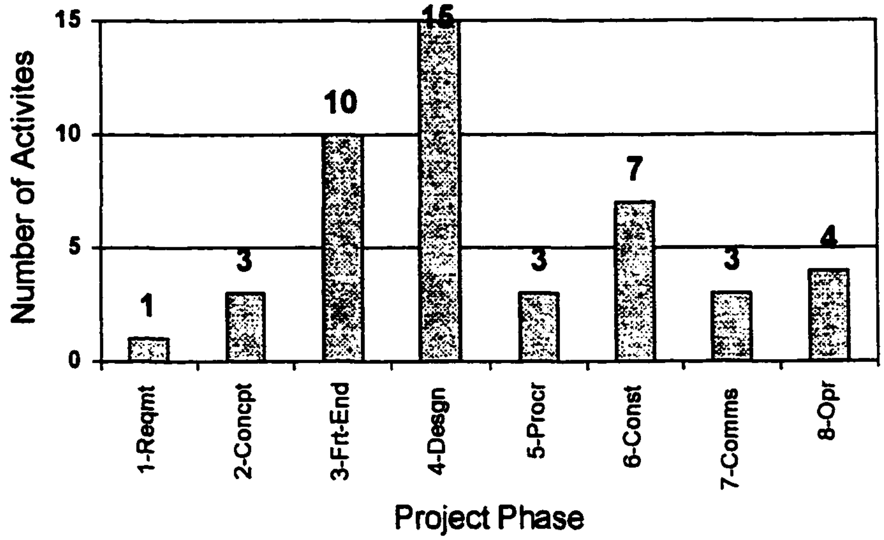

Figure 1.1 Phase Distribution of Model Activities

A flow chart of the Planning for Startup model and the inter-phase relationship between the planning activities is shown in figure 1.2. A listing of the planning activities included in the Planning for Startup model is presented in table 1.1.

Each of the 45 planning activities in the model is described in a detailed one-page activity profile consisting of nine data fields of descriptive information about how the activity is to be completed. A summary of the information fields is presented in table 1.2.

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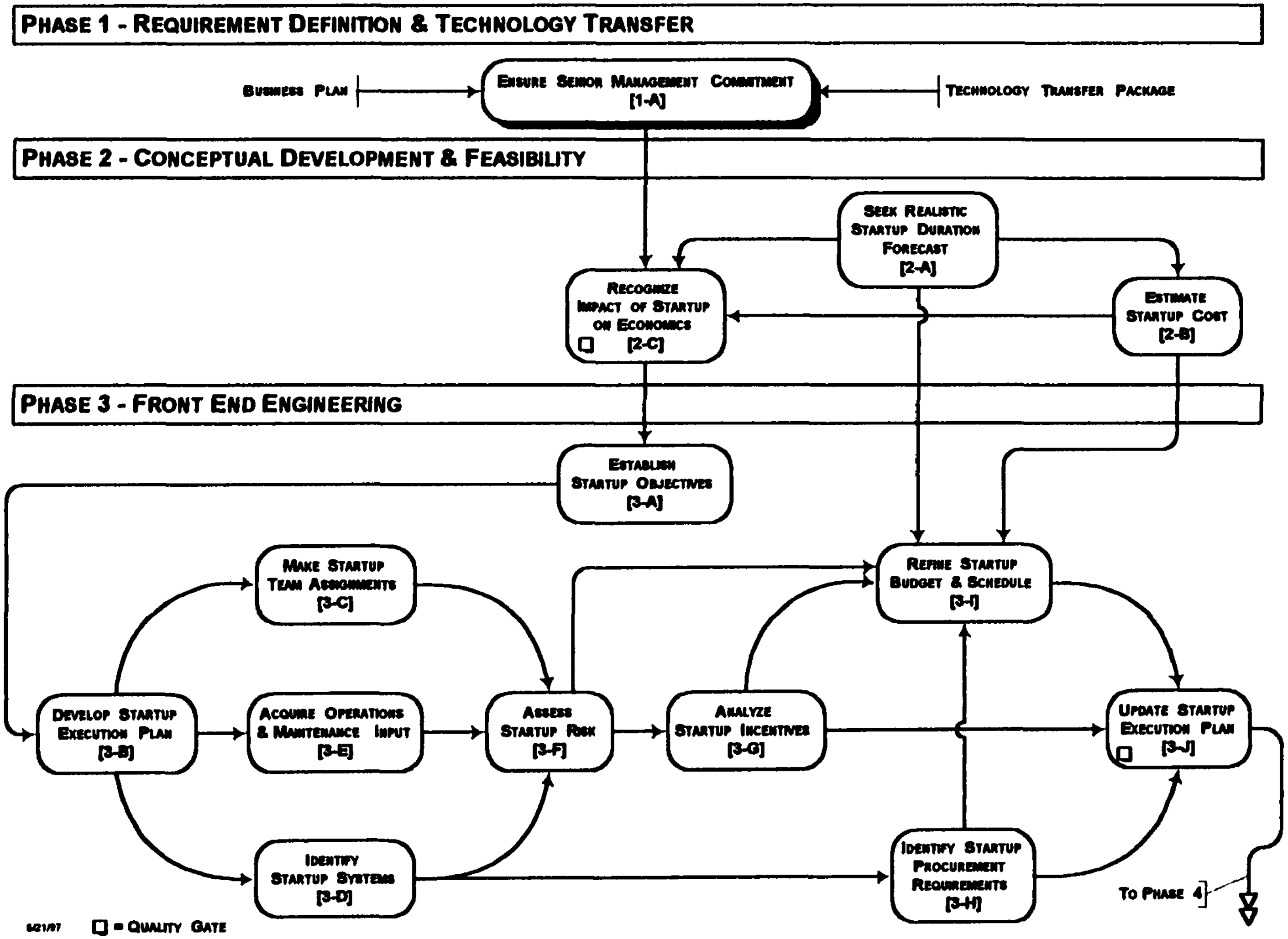
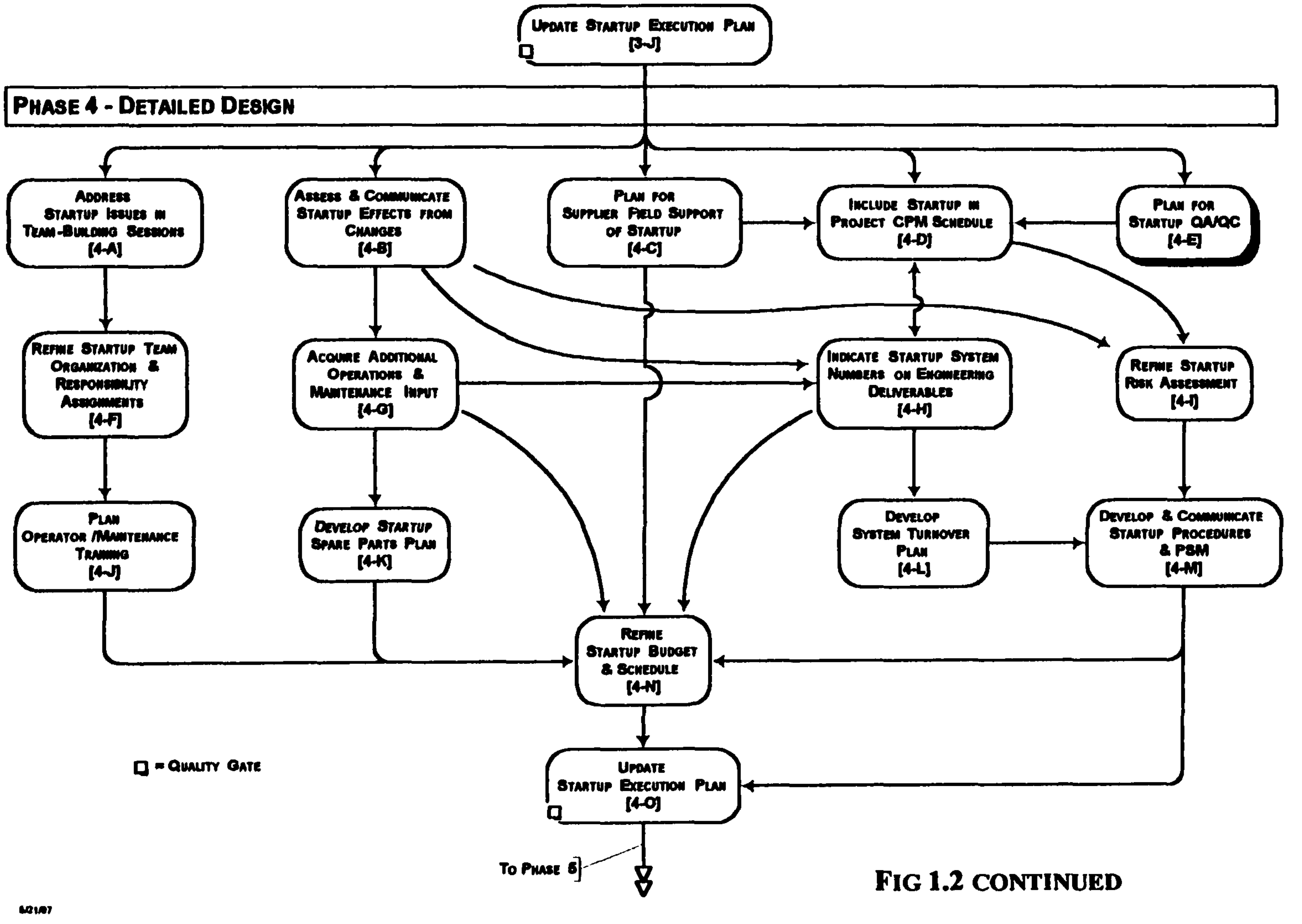


FIG 1.2 PLANNING FOR STARTUP MODEL (CII 1998)



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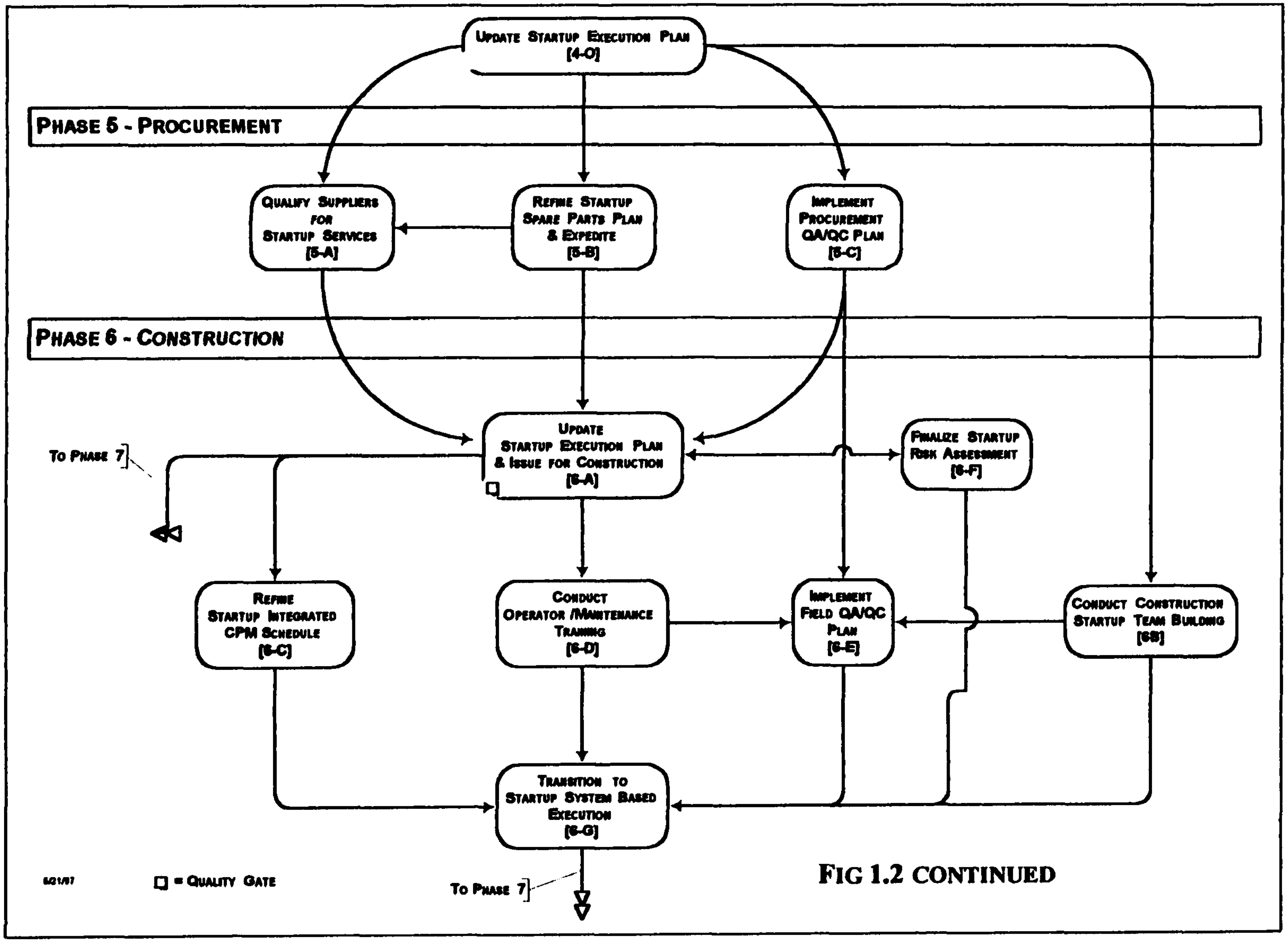

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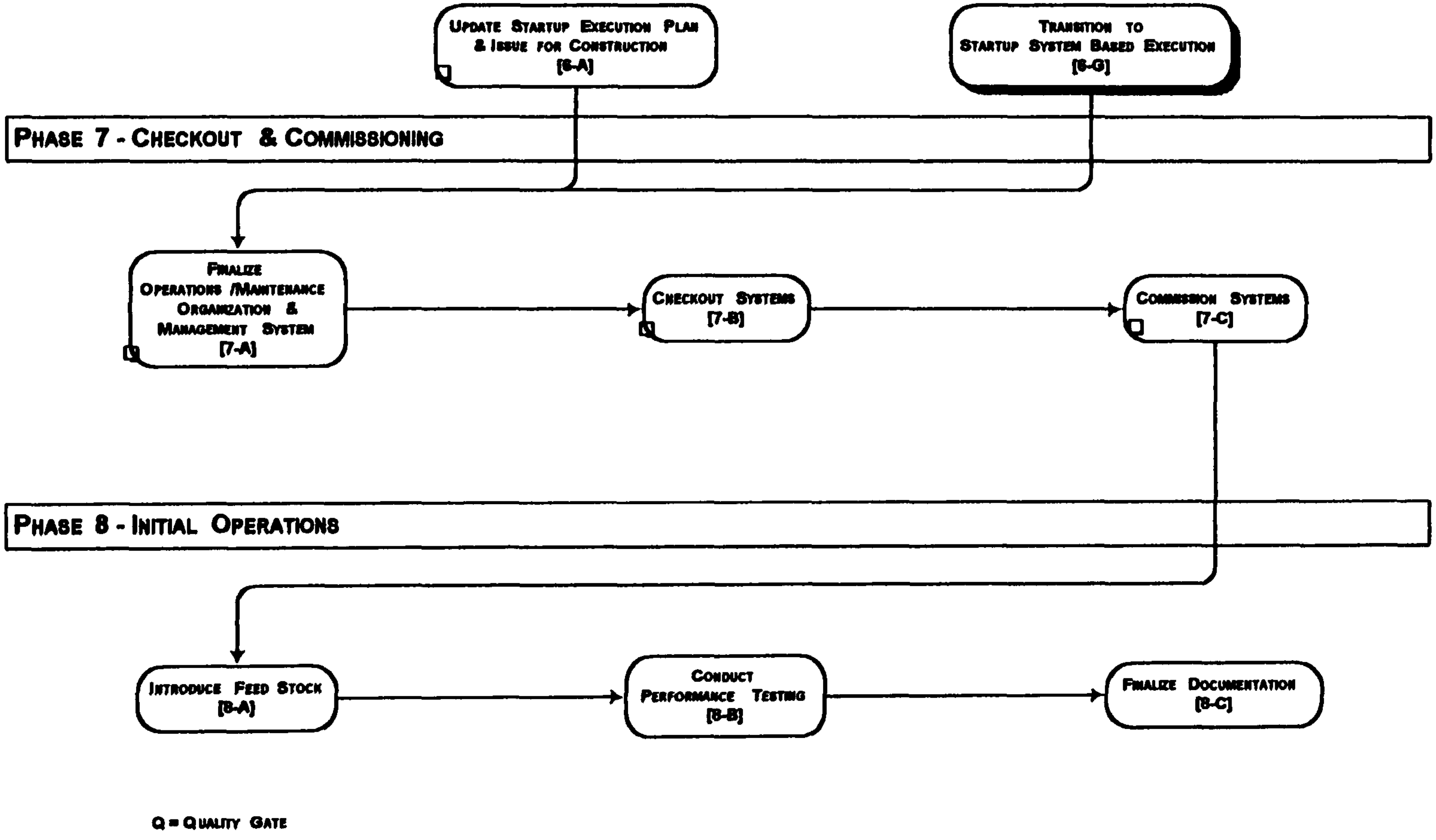

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FIG 1.2 CONTINUED

Table 1.1 Activities in the CII Planning for Startup Model (CII 1998)

Model ID	Activity Description
Phase 1 - Requirements Definition	
1-A	Ensure Senior Management Commitment to Integrated Startup Planning and Needed Resources
Phase 2 - Conceptual Development & Feasibility	
2-A	Seek a Realistic Forecast of Startup Duration
2-B	Estimate Startup Costs
2-C	Recognize the Impact of Startup on Project Economics
Phase 3 - Front-End Engineering	
3A	Establish Startup Objectives
3-B	Develop the Startup Execution Plan
3-C	Make Startup Team Assignments
3-D	Identify Startup Systems
3-E	Acquire Operations & Maintenance Input
3-F	Assess Startup Risks
3-G	Analyze Startup Incentives
3-H	Identify Startup Procurement Requirements
3-I	Refine Startup Budget & Schedule
3-J	Update the Startup Execution Plan
Phase 4 - Detailed Design	
4-A	Address Startup Issues in Team-Building Sessions
4-B	Assess & Communicate Startup Effects from Changes
4-C	Plan for Supplier Field Support of Startup

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Table 1.1 - Continued

Model ID	Activity Description
4-D	Include Startup in the Project CPM Schedule
4-E	Plan for Startup QA/QC
4-F	Refine the Startup Team Organization Plan and Responsibility Assignments
4-G	Acquire Additional O&M Input
4-H	Indicate Startup System Numbers on Engineering Deliverables
4-I	Refine Startup Risk Assessment
4-J	Plan Operator/Maintenance Training
4-K	Develop Startup Spare Parts Plan
4-L	Develop System Turnover Plan
4-M	Develop and Communicate Startup Procedures and Process Safety Management
4-N	Refine Startup Budget and Schedule
4-O	Update the Startup Execution Plan
Phase 5 – Procurement	
5-A	Qualify Suppliers for Startup Services
5-B	Refine the Startup Spare Parts Plan and Expedite
5-C	Implement the Procurement QA/QC Plan
Phase 6 – Construction	
6-A	Finalize the Startup Execution Plan
6-B	Conduct Construction-Startup Team Building
6-C	Refine the Startup Integrated CPM
6-D	Conduct Operator/Maintenance Training
6-E	Implement the Field QA/QC Plan

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Table 1.1 - Continued

Model ID	**Activity Description**
6-F	Finalize the Startup Risk Assessment
6-G	Transition to Startup Systems-Based Execution:
Phase 7 - Checkout & Commissioning	
7-A	Finalize the Operations & Maintenance Organization and Management Systems
7-B	Check-Out Systems:
7-C	Commission Systems
Phase 8 - Initial Operations	
8-A	Plan Initial Operations
8-B	Introduce Feedstocks
8-C	Conduct Performance Testing
8-D	Finalize Documentation

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Table 1.2 Information Fields in the Planning for Startup Model

Data Field	Data Description
Phase	Associated project phase
Key Concepts	Main purposes of the planning activity
Motive/Rationale	Primary reason(s) for executing this activity
Responsibility/Accountability/ Consult/Inform (RACI)	Matrix for assignment of planning roles to project participants
Quality Gate/Sequencing Constraint	Check-point for assessing the quality of previous planing activities and needs for more planning data or tools input
Basic Steps	Component tasks in accomplishing the activity
Tools Needed/Provided	Tools needed for implementation that should be developed; tools provided with the model
Challenges to Successful Implementation	Common obstacles to be avoided during the execution of this activity

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The Planning for Startup model represents a consensus of experience and practice from a broad spectrum of companies, industries and managers and is a distillate of many startup plans from many companies. For a complete view of the model including activity profiles and tools readers are referred to the CII Report 121-11: Planning for Startup: Analysis of the Planning Model and Other Success Drivers (O'Connor et al. 1999) and CII Implementation Report IR121-2: Planning for Startup (CII 1998).

1.3 RESEARCH OBJECTIVES

The primary objective of the research was to validate the CII Planning for Startup model and to identify planning activities that significantly contribute to startup success. Data from project-specific questionnaires and in-depth interviews were used to test the relationship between the level of startup planning (a measure of the level of model implementation) and the timing of startup planning, with the level of startup success. The specific objectives for the research included:

1. Develop a method to measure startup success and determine its relationship to overall project success.
2. Identify and assess the importance of other project factors including; industry type, project size, technology development, and management experience on startup success.
3. Determine the relationship between level of startup planning effort and startup success.
4. Determine the significance of activity timing or activity initiation on startup success.

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5. Analyze management and project characteristics related to startup including planning and startup duration; assignment of the startup manager; the use of startup incentives; and identification of startup systems.

1.4 RESEARCH PLAN

A flowchart of the research effort is presented in figure 1.3. It shows the scope of the research effort and the interface points with the CII Planning for Startup Research Team.

The research effort was organized into four phases of work with a combined total of 16 research activities. An overview of the phases is described below:

- Interview Guide And Development Phase. This was the initial phase of the research effort. The work included a literature review, the development of the basic data collection instruments including the Startup Success questionnaire, the Project Success questionnaire and the Startup Planning Interview guide.
- Data Collection Phase. This phase included setting up interview with project managers, conducting the interviews, and development of the sample database
- Data Set Development Phase. The objectives in this phase were to convert the interview data into a usable data set for analysis. The activities included development of the metric for measuring startup success (the Startup Success Index), and the startup planning metric (the SuPER tool score).

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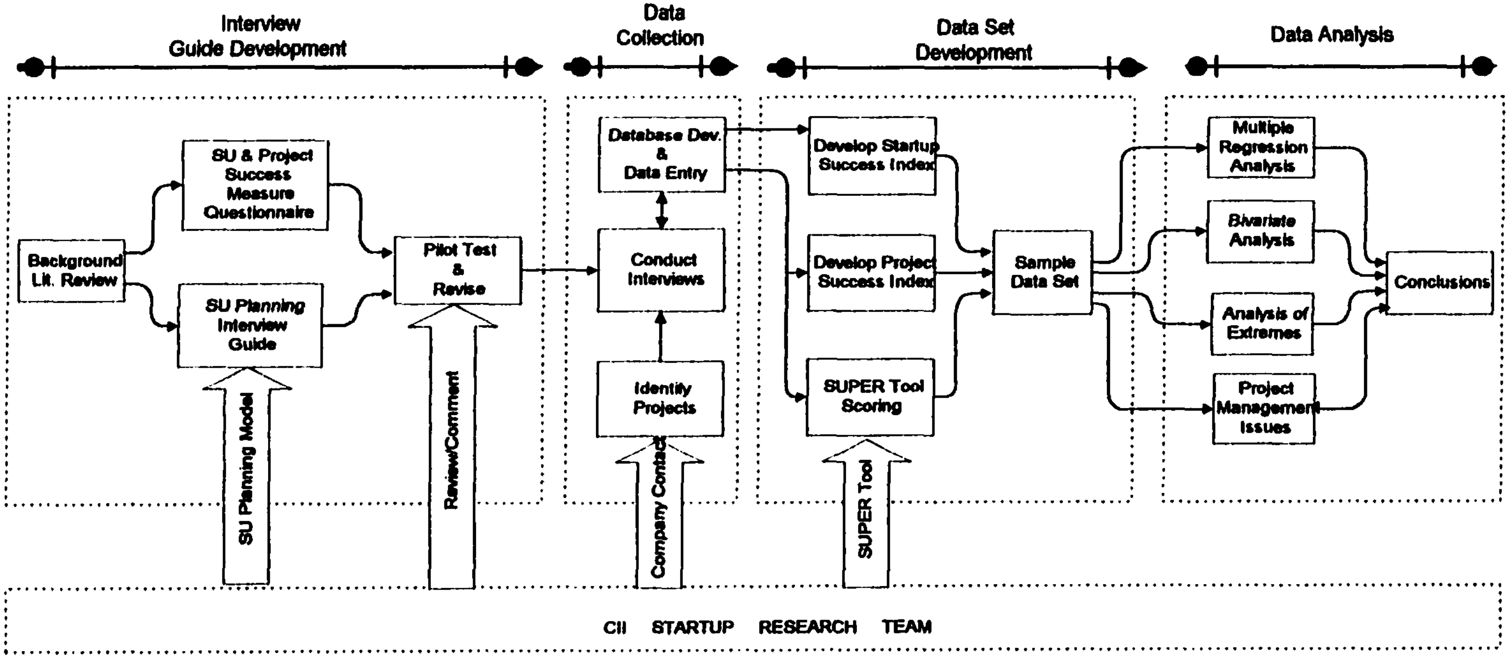

Figure 1.3 Research Plan Flow Chart

- Data Analysis Phase. The sample data set is analyzed using a variety of statistical techniques. Factors that affect startup success are identified; model activities are tested for their significance to startup success. Conclusions and answers to the research objectives are addressed

1.5 DISSERTATION ORGANIZATION

The remainder of the dissertation is organized as follows:

- Chapter 2 presents a summary of reported literature results.
- Chapter 3 presents the research methodologies used for data collection and data analysis.
- Chapter 4 characterizes the interview data including the type of projects included in the data set and the background of the interviewees. A research data set is defined.
- Chapters 5 and 6 present the findings from the analysis of the research data set.
- Chapter 7 presents the overall conclusions and recommendations from this research.

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Chapter 2 Literature Review

In this chapter a summary of the relevant published literature on startup success measurement and startup planning is presented. The reviewed literature includes publicly available articles and proprietary startup manuals provided by the CII Planning for Startup team. The focus of the literature reviewed included the following areas:

- Startup Definition
- Startup Costs and Schedules
- Startup Planning
- Startup Success
- External Factors

2.1 STARTUP DEFINITION

The term "startup" can be defined in a number of ways depending on the industry sector. In general terms, startup is that phase of the project between construction and commercial operations.

Startup typically begins with the introduction of raw material and ends with a successful acceptance test and transfer to a plant operations group. Feldman (1969) suggests the end of startup, or the beginning of commercial or "normal" operations, can be measured in three ways:

- The plant operates at a certain percent of design capacity.

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- The plant is capable of continuous operation for specific number of days.
- The plant is capable of producing a product at a specified level of purity.

Many pre-startup or commissioning activities must occur prior to startup. Gans and Fitzgerald (1966) defined these pre-startup tests to include "mechanical completion" and pressure testing of equipment and vessels, followed by hot runs, water runs and solvent runs, if needed. This view is consistent with the Construction Industry Institute's report (CII 1990) on startup which described a pre-commissioning phase consisting of component and subsystem cleaning and check-out culminating in the schedule milestone – "mechanical completion". This milestone is followed by the commissioning phase, which involves system(s) testing using a test medium that simulates the process material, but at a lower level of risk. "Startup" begins when feedstock is introduced to a "system".

2.2 STARTUP COSTS AND SCHEDULE

2.2.1 Definitions

An explicit definition of startup is important as it has a number of repercussions related to cost accounting and taxes. Because startup definitions vary from company to company, cost accounting methods also vary.

Weaver and Bauman (1973) defined startup expenses as the non-recurring costs between the completion of plant construction and the beginning of

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acceptable plant operations. Startup expenses include startup labor, minor alterations to equipment and piping, and pre-commercial operational costs. Typically, construction changes (i.e. major modifications to piping or equipment) are capitalized and not included in startup costs, while production costs during startup (i.e. operating labor, raw materials etc.,) are expensed and included in startup costs.

The cost of a startup is significant and variable depending on the type of plant undergoing startup and the method of how startup costs are defined. As a general guide, the total cost of startup of chemical plants seldom exceeds 10 % of fixed capital costs (Weaver and Bauman 1973). For startup of non-nuclear power facilities, startup costs are approximately 1 – 2 % of the total project costs (Barton 1980)

In one of a series of reports by the Rand Corporation on the "Pioneer Plants Study Database", Myers et al. (1986) reported that startup costs for new process plants averaged approximately 5.5% of fixed capital costs. The study concluded it was easier to define startup costs than to measure them, which contributes to the problem in making accurate projections.

The measurement problem stems from differences in company cost accounting procedures for handling startup costs. Some companies expense startup costs, which are tax deductible, while other companies capitalize startup costs and amortize them over several years. In practice this accounting issue may not be as significant as originally thought because of the types of costs that are incurred during startup.

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In the Rand study of 56 projects, Myers et al. (1986) found that 80% of total startup costs were charged to the project's capital budgets. These charges are probably appropriate because most of the reported startup expenditures were for replacement or redesign of capitalized equipment that failed during startup.

2.2.2 Modeling Startup Costs and Schedule

Feldman (1969) was one of the first researchers to model mathematically the cost and time associated with startups. In a study of large (1,000-1,400 tons/day) air-separation and ammonia plants, models were developed to predict startup time and startup costs. The model included the following variables:

- Newness of the process
- Newness of the equipment type(s)
- Quality and quantity of labor available for startup
- Degree of interplant dependency

A small data set and unclear definitions for startup costs and startup duration limited the study.

The Myers study (Myers et al. 1986) is one of the most complete, published analyses of startup costs and schedules for the process industry. It used multiple-regression modeling to assess the factors affecting startup time and startup costs from 56 projects. The study found that startup time (i.e. the duration of the startup) was significantly related to the following variables:

- Number of commercially unproven process steps

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- Proportion of heat and material balances from previous commercial units
- Type of feedstock (unrefined solid feedstock vs. all other types of feedstock)
- Presence of a representative project management team (i.e. representative vs. non-representative)

The data set did not contain information on all of the above four parameters so the data set was divided into 2-subsets--one with the representative project management data, the other without. Two regression equations, one for each data set, were developed to statistically test the following conceptual model:

[Duration of Startup] = f (The number of new process steps, the degree of commercial experience with the process, the "Feedstock Factor", and the "Representative Management Factor")

The conceptual model represents an important development because the data set is a combination of continuous and discrete categorical or " dummy" variables. In the studies previously described, the variables were assumed to be continuous variables and measured using response data from questionnaire surveys. The addition of the dummy variables, Feedstock Factor and Representative Management Factor into the regression equation is noteworthy as it allows <u>categories</u> of data to be statistically analyzed.

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In the analysis of the data set without the Representative Management Factor, the Feedstock Factor (i.e. the feedstock type) was shown to be statistically significant. However, when the available Representative Management Factor data was included in the regression analysis, the Feedstock Factor proved to be statistically insignificant, suggesting that the conceptual model was not adequately specified. The best-fit linear regression model for this latter data set

$$\begin{aligned}[\text{Startup Duration}]_{\text{Weeks}} = {} & 6.78 + 2.78 * [\text{Number of New Process Steps}] \\ & - 0.097 * [\text{\% of Balances from Commercial Plants}] \\ & - 5.321 * [\,D_{\text{Representative Management Factor}}\,]\end{aligned}$$

$R^2 = 0.70$

$P < 0.05$

was:

In a similar analysis using startup costs, the factors related to estimating startup costs were closely related to:

- The number of new process steps
- Material handling characteristics such as the abrasiveness of the material and waste handling characteristics
- Whether the plant feedstock is unrefined or solid

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The best-fit linear equation for this data set was:

$$[\text{Startup Cost}]_{(\%\ \text{of Capital}\ \$)} = -0.062 + 2.61 * [\text{No. of New Process Steps}] + 1.04 * [\text{Avg. Level. of Materials Difficulty}] + 2.90 * [D_{\text{Feedstock Factor}}]$$

$R^2 = 0.73$

$P < 0.05$

While the Myers et al. study focused primarily on the quantitative aspects of startup duration and cost, it also demonstrated how management of the project team also affects startup success. They found a high correlation between how the team is structured with both startup duration and startup difficulty. When a project team was held responsible for a successful startup and structured to include representatives from research and development (R&D), engineering, and operations, startups were considerably shorter and smoother than in startups where the project teams were not diversely integrated.

2.3 STARTUP PLANNING

The literature on the management and planning of startup typically begins with descriptions about "lessons learned" from either not-so-successful or very successful startups. For example, in 1968 Conoco started up a new 500 million-

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lb./yr. ethylene plant, and even though it was the first ethylene production plant for the company, it was started up in a record 8 days. This success was attributed to an extensive startup planning and training effort between the contractor, the owner, and the owner's operation teams (Chemical Engineering 1968).

Similarly, Feldman (1969) describes the disastrous results of Union Carbide's experience during the startup of a new chemical plant located in Taft, La. The problems were so great it affected the entire corporation by reducing Union Carbide's after-tax earning by $30 million and earnings per share by $0.34.

Over the last 30 years, the approach to startup planning has evolved from the "build it, turn it on, and see what happens" to a much more disciplined and planned activity. Early on, separate startup organizations were essentially non-existent. Typically, the design engineer in conjunction with the owner's operating personnel performed much of the testing and startup. In the power generation industry the transition to a structured planning effort occurred in the 1960's when plant sizes increased above 1,300 mega-watts (MW) and control systems became much more complex. Startup of nuclear facilities catalyzed the movement to a more formal startup planning process when, in 1972, the Nuclear Regulatory Commission issued rules and regulations requiring a formal startup and testing program (Barton 1980).

In the 1966 book, "The Chemical Plant--From Process Selection to Commercial Operations" Gans and Fitzgerald (1966) assert that the appointment of a qualified startup leader is the most critical aspect of startup planning. The leader should be appointed during the design phase and should be required to

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supervise the various aspects of startup planning, including development of staffing plans, development of the operations and training plans, and establishing the filing structure for plant equipment and operation and maintenance manuals. Gans and Fitzgerald also recognized that as the number of new processes increased so should the level of startup planning.

Barton (1980) describes a startup-planning program for power plants. The startup planning should begin during the early stages of construction. Ideally the startup leader should be appointed 18-24 months before startup to give adequate time to develop the test plans and procedures. At a minimum, the startup plan would include the following steps:

- A complete listing of all systems and major components including a list of all tests required for each.
- An organization chart identifying the key startup personnel.
- A startup and test logic diagram for scheduling all identified tests.
- A project test manual and all administrative processes for conducting and documenting the startup performance.

Two options for organizing the startup effort were presented: 1) An owner lead effort with support from the design engineer and constructor, and 2) A "Third Party Organization" approach where the startup is contracted to an outside startup company. After startup, the plant is turned over to the owner for operations. The latter approach was viewed as too risky and contractually cumbersome: An owner- lead effort was strongly recommended.

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Barton (1980) also advocates the formation of a diverse "test-working group" (TWG) to implement the startup plan. The objective of the TWG was to provide continuity between the construction and startup phase of the project and provide coordination for the overall startup effort. The TWG should be comprised of members from the following organizations:

- Owner startup team
- Design engineer
- Operations
- Steam supply representative
- Constructor

This group should be charged with the responsibility for preparing a detailed startup-testing program.

In 1982 Fulks, an engineer with the Union Carbide Corporation, published a detailed description of the steps necessary for planning and organizing a startup. It represents one of the first attempts to describe the processes, sequences and responsibilities for a successful startup (Fulks 1982).

The first recommendation, which was a significant departure from earlier articles, was to begin the startup planning effort during the Project Definition stage of the project. The article went on to present a phase-by-phase list of milestone activities necessary for developing a startup plan. The following major milestones were recommended:

- Project Definition Phase. Initial startup planning
- Process Design Phase. Issue preliminary startup plan

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- Detail Design Phase. The preliminary startup plan is refined and the responsibilities between the startup group, the plant operations group and constructor are defined.
- Construction Phase. The startup team is assembled and trained. The detailed startup plan and plant operations plans are completed approved and issued.
- Startup Phase. The startup plan is executed and the plant begins production to a preset capacity. Typically this would be below the plant's design capacity but identifying a capacity goal defines the end of the startup phase and allows identification of subsequent tasks necessary to get the plant up to full design capacity.
- Debottlenecking Phase. This phase is led by the operations group and involves the operational improvements necessary to optimize the plant's production capacity.

Fulks also stressed the role of vendor support and equipment purchasing. He emphasized the importance of good coordination between the purchasing department and the plant-engineering group. Methods to improve coordination between the groups are described.

This observation is consistent with reports by others (Finneran et al. 1968; Gans 1976; Myers et al. 1986). These reports found that equipment failure is the reason most often cited for startup failures, reinforcing Fulks' conclusion that diligent coordination with equipment suppliers is critical to a successful startup.

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Baasel (1990) describes some of the precommisioning tasks required for startup including line flushing, dynamic testing, and instrument and control system checkouts. He asserts that startup planning cannot begin too early in a chemical plant project, and at a minimum, must be started during the design phase of the project.

One the most dramatic demonstration of the benefits of early startup planning is U.S. Steel's (USX) mill modernization project for the Gary Works (Prospero and Evans 1996). The Gary Works is USX's primary mill for rolled steel. It processes approximately 60% of USX's rolled stock and is a major supplier to the automotive industry. Customers were demanding a higher quality and more consistent product and USX was committed to these needs if, the project could be accomplished without a protracted outage or slow startup. In summary, the business interests of USX demanded a "zero learning curve startup".

In response to this goal the management team developed DFSU (Design For Start Up), a project execution approach whose goal was to implement all of the mill's modernization improvements without shutting the plant down except for normal maintenance outages. The business interest of USX determined that the plant could not be taken out of service for an extended period and USX could not accept any startup problems at the end of a maintenance outage period. To meet these goals, the DFSU concept adopted the following guiding principles:

- Full equipment testing
- A multifunction project management team

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- Application of only proven process technology

Full equipment testing was viewed as the most important activity and several management strategies were utilized this goal including:

- Direct contracting with all major equipment suppliers. Equipment selection was predicated not only on low bid but also on the commitment of major suppliers to the DFSU process and participation in the Vendor/Supplier Team.
- Extensive witness testing of the equipment at the suppliers facility.
- Use of test stands (i.e. exact replicas of the main mill stand) to practice the assembly and testing of all inter-stand equipment prior to final installation.

To implement these strategies it was necessary to assemble a multifunction project team consisting of the following groups:

- Company Core Team. Essentially the owner's project management team which, in this project, also acted as the general contractor for the project.
- Company Support Team. This was the owner's operation and maintenance team--the ultimate customer for the delivered project.
- Vendor/Supplier Team. A team made up of the equipment suppliers including mechanical, electrical, instrumentation and control subcontractors.

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USX viewed this project as very successful because the startups proceeded without difficulty and without any interruptions of normal mill operations other than scheduled maintenance outages.

Prospero and Evans (1986) reported that immediately after startup, the facility went on to set a North American monthly production record for strip mill production and, within a year, the plant went on to set a world record for annual production of rolled steel. These results clearly demonstrated the ability of the DFSU process to meet the objectives of the project. No startup cost data were presented.

2.4 STARTUP SUCCESS

An extensive literature search was conducted to identify methods for defining startup success: None were found. Rather, the search lead to a wealth of information on project success. The objective of the literature review focused on understanding the literature on project success, which could then be applied to developing methods for quantitatively measuring startup success.

In the chapter on "Factors Affecting Project Success" of the *Project Management Handbook*, Baker et al. (1983) posed the question:

> ***"Why are some projects perceived as failures when they have met all the obvious measures of success such as completed on time; completed within budget; and met all technical specifications?"***

In a survey of over 650 projects the researchers identified a number of project management attributes (e.g. "Minimal Startup Difficulties") and

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parent/sponsor attributes (e.g. "Projects with complex legal/political environments") that affect the perception of success.

Baker et al. concluded that technical performance is integrally associated with perceived success, whereas cost and schedule performances are less important. Furthermore, good schedule and good cost performance mean very little to overall project success if the end product does not meet the desired performance of the project. They defined a successful project as a project that:

- Met the project's technical specifications and/or project mission
- Attained high levels of satisfaction from the parent company, the client, the users and the project team

Implicit in this definition of success is that the level of success will vary depending on: 1) the role of the person or group i.e. the project manager, the owner, the operations group; and 2) the timeframe in which project success is measured.

In a study of 103 development projects ranging in size of $10,000 to $550,000,000, Might and Fischer (1985) evaluated the relationship between "project management success" and three structural components including: 1) organizational structure; 2) managerial authority; and 3) project size.

Project management success was defined as a multiple objective function with following parameters:

- Overall success. A subjective perception of the overall success of the project

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- Cost success. An objective parameter measured as a percent of original budget
- Schedule success. An objective parameter measured as a percent of the initial schedule estimate.
- Technical success. Subjective measurements of the technical success of the project relative to:
  1) the goals of the project;
  2) other development projects in the firm; and
  3) the technical problem identification process.

Project data were collected using questionnaires and the data responses scored using a seven-point scoring scale. The data was subdivided in population categories and then the differences between the categorical mean scores were tested using t-test statistics. Typically, a significance value (P) < 0.1 was used to accept or reject hypotheses. The results showed that project management success was highly correlated with managerial authority but not with either organization structure or project size.

Slevin and Pinto (1986) interviewed 60 project managers to determine the critical factors in successful project implementation. They identified ten critical success factors that, in the opinion of the interviewees, were critical to success. These critical factors for successful project implementation included:

- Clearly defined project mission
- Top management support
- Detail project schedule/plan

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- Client consultation
- Personnel issues
- Technical tasks
- Monitoring and feedback
- Communication
- Trouble-shooting

In a follow-up study, the same authors (Slevin and Pinto 1987) described a metric, the "Project Implementation Profile" or PIP, to measure how well these ten critical success factors were implemented. The authors hypothesized that a project with high PIP (i.e. a project with a high-level success factors implementation) should result in a higher level of project success.

In 1988 Pinto and Slevin (1988) conducted a survey of over 400 projects to further assess the relationship between their 10-factor PIP model and project success. As an improvement to the original PIP metric, four "external factors" were added to the model including:

- Characteristics of the project team leader
- Power and politics, or the perception that the project was furthering an organization member's self interests
- External factors such as external organizational or environmental factors that impact the project team
- Urgency factor, or the perceived importance of completing the project

Based upon the results of the survey information the following conceptual model of project success was proposed:

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[Project Success] = f (Adherence to Budget, Adherence to Schedule, Level of Performance Achieved, Technical Validity, Organizational Validity, and Organizational Effectiveness)

With the addition of the project success information the PIP metric provided a quantitative mechanism to relate specific project performance factors with project success. The research also demonstrated that a project's level of success is very dependent on when the success measurement is taken. The researchers categorized their survey data into one of four project phases including:

- Conceptualization Phase. The phase when top management sees a strategic need for the project.
- Planning Phase. The project has been authorized. The core project team is assembled and a project execution plan is developed.
- Execution Phase. The project plan is executed.
- Termination Phase. The project is turned over to its intended users.

The researchers used linear regression techniques to assess the relationship between each of the critical factors with project success and project phase. For each of the four project phases, a stepwise multiple regression technique was used to determine the strength of the relationship between project success and each of the 14-critical factors (i.e. the ten-factor PIP model plus the four "external factors"). At each step, a critical factor was added to the regression equation and

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the regression statistics computed. If the significance value (p value) was below 0.01 the success factor was retained and the next step began. The reported adjusted R^2 for the models tested ranged between 0.45 and 0.66.

The results showed that the type and number of components of project success was strongly related to the phase of the project. A summary by phase of the significant factors in measuring project success is presented in table 2.1.

Table 2.1 Project Success Factors by Project Phase (Pinto and Slevin 1988)

Project Phase	Significant Success Factors
Planning Phase	1. Clearly defined mission 2. Client acceptance 3. Top management support 4. Urgency factor
Execution Phase	1. Clearly defined mission 2. Characteristic of project team leader 3. Detail project schedule 4. Troubleshooting 5. Client consultation 6. Fulfillment of technical tasks
Termination Phase	1. Clearly defined mission 2. Client consultation 3. Fulfillment of technical tasks

In a related study of projects for the process industries, O'Neill (1989) defines project success as a function of the phase of the project and project performance in three critical areas: 1) schedule; 2) cost; and 3) quality. What makes the O'Neil discussion important is the contention that startup success can

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be measured in terms of the quality of the turnover of the constructed facility to the operating staff. The introduction of the concept that the project group "transfers" or turns over the project to the operations group is an important one as it implies that one component of startup success could be measured as the success or ease of this transfer process.

In a study of the automation industries in Taiwan, Tan (1996) evaluated the promoters, facilitators and barriers that affected the transfer of industrial research to industrial users. The study used questionnaire data from project managers to evaluate 48 projects including 28 "successful" and 20 "not-so-successful" projects. (Note: This initial success categorization was based upon the project manager's perception of the project's success.) Project success was measured by scoring, on a seven-point scale, the project's manager's level of satisfaction with three performance criteria:

- Overall Performance. A general, overall level of satisfaction score.
- Recipient Satisfaction. The perceived level of satisfaction of the project's "customer". This included assessing the customer's level of "User Satisfaction" and the extent of "User Utilization".
- Satisfaction of the Transfer Process. The perceived level of satisfaction with the project delivery process that included: 1) Meeting budget objectives; 2) Meeting schedule objective; and 3) Assessing the smoothness of the transfer process.

Respondents were then asked to measure the importance 48 statements grouped into nine Success Factors such as Technical Characteristics, User

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Involvement, and Project Team Characteristics. An example of an importance statement for "User Involvement" was: " The recipient is involved at the early stage." The project manager would the assess the importance of this statement in the project success by scoring his agreement on a scale of 1 to 7: 1 being "strongly disagree" and 7 being "strongly agree".

Multiple regression analysis was used to test the strength of the relationship between the Success Factors and the Success Criteria. The results showed that the level of satisfaction with the success of the Transfer Process was significantly related to:

- Meeting functional objectives
- Meeting budget objectives
- Meeting schedule objectives
- Smoothness of the transfer process

The best fit linear equation for measuring the transfer success was:

$$\begin{aligned}[\text{Transfer Process Satisfaction}] = {} & 0.322 * [\text{Tech Characteristics Score}] \\ & + 0.562 * [\text{User Involvement Score}] \\ & - 0.224 * [\text{Mgmt Support Score}] \\ & + 0.350 * [\text{Infrastructure Support Score}]\end{aligned}$$

$R^2 = 0.96$

$P < 0.01$

Gibson and Hamilton (1994) used project data from 62 recently completed projects to evaluate statistically the relationship between the level of a project's

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pre-project planning effort to its success. One of the prime efforts of the research was to develop the Project Success Index (PSI), a quantitative measure of project success. The index was developed based on an analysis of questionnaire data from project managers and bivariate regression modeling. Using regression analysis they were able to statistically evaluate the relationship between the PSI and a variety of pre-project planning variables. The research identified four factors that contributed to the Project Success Index:

- Budget Success Value. Adherence to authorized budget measured as a percent (%) deviation of actual versus authorized.
- Schedule Achievement Value. Adherence to authorized schedule for mechanical completion measured by a percent (%) deviation of actual versus authorized.
- Design Capacity Attained. Design capacity defined as the nominal output rate used during engineering design of equipment. Measurement was the percent (%) of planned capacity at authorization attained after six months of operation.
- Plant Utilization Attained Value. Plant utilization was defined as the % of days in a year the plant actually produces product. Measurement was the percent (%) of planned level attained after six months of operations.

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The best fit regression model for the Project Success Index was:

$$
\begin{aligned}
\text{[Project Success Index]} = {} & 0.33 * \text{[Budget Success Value]} \\
& + 0.27 * \text{[Schedule Achievement Value]} \\
& + 0.28 * \text{[Design Capacity Attained Value]} \\
& + 0.12 * \text{[Plant Utilization Attained Value]}
\end{aligned}
$$

$R^2 = 0.42$

$P = 0.05$

Shenhar et al. (1997) conducted a study to evaluate further the dimensions of success and the effects of timing on its measurement. Using survey data from 127 recently completed projects, 13 measures of success were defined and then grouped into the following four broad dimensions:

- Project efficiency
- Impact on the customer
- Business and direct success
- Preparing for the future

These dimensions of project success were then categorized into two time dependent categories: "immediate success" and "commercial success". For example, project budgets and project schedules were components of "project efficiency" and were attributes of "immediate success". This dimension of project success would be measured at the end of the project whereas the project's "commercial success" would be measured after a period of extended operation.

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Pearson's correlation coefficient was used to assess the strength of the relationship between the overall success scores and the success scores for each success factor. Significance values for hypothesis acceptance testing ranged from 0.001 to 0.01.

The research of Shenhar et al. research extended the work of Pinto and Slevin by showing statistically that the dimensions of project success and their relative importance will vary with time and the perspective of the group making the measurement.

2.5 EXTERNAL FACTORS

To this point, the reviewed literature has focused on internal success factors such as project planning and project organizational factors, which to some extent can be controlled or anticipated. Most projects however operate in a larger realm where external factors outside of the direct control of the project team can affect its success.

In a study involving 56 process plants constructed in the United States and Canada, Myers et al. (1986) investigated the effect of external factors on construction schedule slippage. The authors defined external factors as:

- Bad weather
- Strikes
- Labor shortages
- Material shortages/equipment delays.

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In the study, participants were asked to estimate the amount of time directly attributable to one of the above external factors. The investigators then analyzed the relationship between schedule slippage and the presence of external factors and concluded that:

- External factors typically do not have a significant effect on schedule slippage. On average, external factors delayed construction by approximately 1 month or, 3.5% of the average total project duration.
- When external effects are present they typically become the primary reason for the schedule slippage and account for approximately 82% of the total schedule slippage.

The researchers concluded that because external factors are not normally present they are not major contributors to construction delays; but when they are present, they will have a significant effect on the construction completion schedule.

Merrow (1988) analyzed regulatory effects on megaprojects (projects with a total installed cost exceeding $500 million) and found that regulatory external factors were the most important predictors of cost growth and schedule slippage. The amount of slippage and growth were shown to be a function of the extent the project encounters regulatory constraints in the following areas:

- Regulatory requirements to protect the natural environment from the effects of the project.
- Protection of the public health and safety from the effects of the project.

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- Controls on the use of labor or procurement.
- Other governmental standards or regulations.

Other studies (Avots 1983; Morris and Hough 1987; Pinto and Slevin 1988) also evaluated the effect of these external factors on project schedule performance and cost performance and have generally concluded that external factors may, but do not always, play a significant role in the outcome of a project. The validity of this research conclusion is somewhat diminished because of inconsistent definitions of what constitutes an external factor. Many management studies use the term “external factor” to capture a host of conditions such as severe weather, company politics, equipment delivery delays, environmental regulations, and labor unrest. In some cases, the term is so broadly applied it appears to fill the role of a “catch-all” term for all of the inexplicable problems in a project. In spite of this, there is sufficient evidence supporting the belief that non-internal factors can dramatically affect the outcome of project.

Economists recognize the existence of external forces and have developed a more rigorous definition for a particular class of external factors called “externalities”. Samuleson and Nordhaus (1989) defined externalities as transaction effects that occur outside of the competitive market place and occur when people, companies or governments impose costs or benefits on others without those others receiving the proper payment or paying the proper costs. Pollution discharges and labor conflicts are typical examples of economic externalities. In the view of economists, these externalities occur during the course of a transaction but their true effects on the economy are not fully captured

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in the transaction cost – governments attempt to account for these lost transaction costs by issuing and enforcing regulations. A similar approach may be useful in assessing external factors that contribute to project success.

2.6 CONCLUSIONS FROM THE LITERATURE REVIEW

In this section a brief summary of the conclusions of the literature review is presented. Its purpose is to present conclusions from the results of other research efforts and to establish a foundation and direction for validation of the PFS model.

1. Relevance of the PFS model. CII's Planning for Startup model (CII 1998) is the most comprehensive startup planning model reported. Others have developed startup plans that addressed portions of the startup planning process but nothing in the reviewed literature addressed startup planning issues to the degree presented in the CII model.
2. Startup success models. There were a limited number of studies that investigated methods for defining or quantitatively measuring startup success. These reports statistically related startup costs and startup schedule performance with project specific components including process complexity and technology maturity. To date, none have investigated the effect of the startup planning effort or the effect of the startup planning timing on the success of the startup.
3. Model validation. Validating the PFS model requires a methodology for measuring startup success. While no direct reports on methods to measure

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of startup success were found, there was an extensive body of work on measuring project success. Conceptually, the project success model measurement is one that can be applied to the development of a similar measure of startup success. These project success studies have demonstrated that an index is an effective method to quantitatively measure startup success.

4. Quantitative approach for model validation. Multiple regression techniques have been shown to be a valid approach to statistically evaluate the relationship between a success index and a success variable. A summary of the typical statistics from previous studies that measured project success is presented in table 2.2. Of those reviewed the approaches used by Gibson and Hamilton (1994) and Tan (1996) offer the best approach for developing the startup success indexes

Table 2.2 Summary of Success Research Using Linear Regression

Referenced Study	Sample Size	Significance value (P) used for hypothesis testing	R^2
Pinto and Slevin(1988)	400	0.01	0.45 – 0.66
Might and Fischer (1985)	103	0.1	Not Reported
Myers et al. (1986)	56/35	0.05	0.70 – 0.73
Tan (1996)	48	0.01	0.96
Gibson and Hamilton (1994)	53	0.05	0.42

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5. Measurement Perspective. Previous studies have shown that the measurement of project success is dependent on the perspective and the period of measurement. Because of the roles and responsibilities of the project and operations teams, startup success is best measured from the perspective of the project and/or operation groups. Both have a vested interest in a successful startup as one group can finish their work and the other can begin. The operations group appears to have a more compelling reason to be interested in startup planning as they play an important role in startup execution and ultimately have the responsibility of operating the completed facility. Their interest is also a long-term one as this will be the first of many startups the facility will undergo during the course of its production life.
6. Period of Interest. The phase of interest should span from the project initiation phase through the startup of normal operations.
7. Startup Information. Startup is typically the owner's responsibility and typically planned by the owner's project manager. Therefore the owner's project manager is the preferred source for startup planning data. Planning information from this perspective will also enhance the credibility and confidence in the outcome of the research.
8. Research Domain The industrial process industry should be the primary area of research data. Startup occurs in virtually every project in this sector therefor this represents the best source of data.

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This concludes the review of the relevant literature on startup. From this review and its conclusions, the conceptual direction and methodologies for validation of the CII Planning for Startup model were developed.

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Chapter 3 Research Methodology

In this section, the research methodologies and tools are presented. Descriptions are organized by research phase and include:

- Development of survey instruments
- Data collection and coding
- Success indexes and SuPER tool development
- Data set analytical methods

3.1 DEVELOPMENT OF SURVEY INSTRUMENTS

Three survey instruments, the Interview Guide, the Project Success Questionnaire, and the Startup Success Questionnaire were developed in the research and served as mechanisms for gathering project data for Model validation. The Interview Guide was developed for use in personal interviews; the Project Success and Startup Success Questionnaires were developed for use either in personal interviews or in mail/fax surveys.

3.1.1 Interview Guide

The Interview Guide was the primary data-gathering instrument in the study. It captured the startup planning data for the Planning for Startup model validation, as well as project facts and startup conditions. The guide was initially developed, and then pilot-tested and revised.

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The guide consists of nine sections, each containing a combination of explicit, "fill in the blank" type questions, Likert response questions, and open-ended short-answer questions. The guide is divided into nine sections as summarized below. A complete version of the Interview Guide is presented in Appendix B.

I. Interviewee Information
II. Identification of Best and Worst Startups
III. Success Ratings, Percentiles, & Factors
IV. Duration and Schedule Analysis
V. Assessment of SU Planning Activities
VI. Project Organization Issues
VII. O&M Participation
VIII. SU System Identification
IX. Lessons Learned

Sections I through IV and VI through IX collect contextual information such as interviewee experience, project costs, and startup duration. Section V: "Assessment of SU Planning Activities" is the heart of the model validation process and is specifically devoted to capturing startup planning data. The questions in this section were developed on the premise that the startup was planned using the activities described in the model. In the interview, the interviewee scores each activity based on the level of effort applied and the

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project phase when it was initiated. Once startup success indices were assessed, model validation then involved the process of determining the degree of agreement between planning activities actually done and planning activities recommended in the model.

The major advantage of this approach was that the interview data was collected in the vocabulary of the Planning for Startup model, and not in the (likely unique) vocabulary of the interviewee's company. A disadvantage was that it required the interviewee to have a clear understanding of the model's terminology and approach. By collecting the data in personal interviews, this disadvantage was minimized.

To elaborate on the model validation process, Section V captures planning data as responses to the following three questions:

- "*How much effort was applied to this activity?*" This question measures the Level of Effort devoted to accomplishing the activity. If the activity was done, the interviewee assigns it a score between "1" and "5" depending on the level of effort expended in completing the activity: If the activity was not done, it is scored "0":
- "*When was this activity first started?*" This question establishes the time of activity execution--the "when". The interviewee selected the project phase when the activity was first started. If the activity was not done i.e., an activity with a zero effort score, the column is left blank.

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- "*How important is this activity?*" The interviewee rates the activity on how important this activity is to any project. Importance is measured on a "1" to "5" scale similar to that used to measure level of effort.

As a detail, all model activities are not included in the Interview Guide. Those model activities that are continuations of previous activities and are not critical to model validation were excluded from the Interview Guide. For example: Model Activity 3-B: "Develop SU Execution Plan" is included, but its follow-on activity 4-O: "Update the Startup Execution Plan" is not. In total, 28 of the 45 Planning for Startup Model activities were included in the Interview Guide. A list of the model activities included and excluded in the interview guide is presented in Appendix A.

The Interview Guide underwent three revisions during the course of the study. One was major; the other two were minor. The major modification was the result of a two-project pilot test that simplified the interview form. The interview time was shortened to approximately four hours (the duration of the pilot interviews approached five hours per interview), and project data was limited to one startup per interview, not two, as originally planned. The subsequent minor revision consisted of format and wording modifications to the guide. Ultimately, all interview data were transformed to the format of the final Interview Guide prior to coding and database entry.

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3.1.2 Startup and Project Success Questionnaires

The Startup Success Questionnaire and the Project Success Questionnaire, as suggested, were developed to gather data for measuring the success of the startup and the success of the project. They provided the raw data for input into the equations for computing the Startup Success Index and Project Success Index. Development of these success indices is discussed later in this chapter, a discussion of the success questionnaires is presented below.

Initially, success data were collected in Section III of the Interview Guide ("Success Ratings, Percentiles, & Factors"), but this data produced inconsistent success scores because of the lack of explicit definitions for the success criteria questions. A decision was made to develop a separate set of questionnaires specifically addressing project and startup success. The objective of the follow-up questionnaires was to improve accuracy and precision of the startup and project success measurements by providing explicit definitions for each success indicator, and to provide a mechanism for measuring the relative importance of each success indicator to the overall objective of the project.

Eight startup success indicators were defined in the Startup Success Questionnaire including:

1. Product quality performance
2. Product quantity performance
3. Schedule performance
4. Safety performance
5. Environmental performance

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6. Operations team performance
7. Impact on on-going operations
8. Level of effort required by the startup team

For each success indicator, five levels of satisfaction were offered ranging from "Extremely Satisfied" to "Very Dissatisfied". Figure 3.1 presents an example of how success data for one indicator, "Product Quality Performance", was collected.

1. Product Quality Performance
At the end of Start Up, what was your satisfaction level with product quality as established at project authorization

Satisfaction Level	Definition
☐ Extremely Satisfied	Product quality consistently exceeded project goals.
☐ Very Satisfied	Product quality goals were consistently met.
☐ Satisfied	Product quality goals were met with expected amounts of off-spec material.
☐ Dissatisfied	Product quality met specification most of the time but the amount of off-spec material was higher than expected.
☐ Very Dissatisfied	Product quality was met only with significant process and construction rework.

Figure 3.1 Example of Startup Satisfaction Definition

Similar definitions were developed for each of the other seven indicators. For a complete presentation of these success definitions see the Startup Success Questionnaire presented in Appendix B.

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The relative importance (or weighting) of each success indicator was selected by the interviewee from the following:

- Most Important
- Above Average Importance
- Average Importance
- Below Average Importance
- Least Important

It was not a requirement that the importance factors be rank ordered. The interviewee could assign the same importance level to all indicators if that was an accurate reflection of the project requirements.

Like the Startup Success Questionnaire, the Project Success Questionnaire measures performance levels with a structured set of variables and performance definitions. Seven success variables are defined in the questionnaire including:

1. Cost Performance
2. Schedule Performance
3. Demonstration of Design Capacity
4. Unscheduled Down-Time
5. Project Safety
6. Environmental
7. Operating Costs

For each project success variable, three categories of performance were presented. An example of how the indicator "Cost Performance" is measured is

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presented in figure 3.2 below. A copy of the complete questionnaire is presented in Appendix B.

Assessment of Project Success Variables
For the Success Variable Question please indicate the level of project performance

Success Variable	Question	Performance
COST PERFORMANCE	*The Total Installed Cost for the Project was....*	☐ Significantly Under Authorized Budget. ☐ Essentially At Authorized Budget ☐ Significantly Over Authorized Budget

Figure 3.2 Example of Project Success Performance Definition

As for the Startup Success Questionnaire, the Project Success Questionnaire also included an Importance Factor score sheet for these success variables. The scoring was like that used in the Startup Success Questionnaire.

3.2 DATA COLLECTION AND CODING

The data collection phase of the research included identifying projects for analysis, setting up interviews with project and startup managers, conducting the interviews, structuring of the database, and entering data into the database. The methods used for accomplishing these tasks are presented below.

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3.2.1 Identification of Projects

Most of the projects studied involved CII members but some non-CII member projects are represented as well. Potential projects and their respective project managers were identified in a two-step process. Initially, a Research Team member identified a project manager with startup planning experience. The project manager was then contacted by telephone and briefly interviewed to determine if he/she had the applicable experience in startup planning and if they had a suitable startup project for inclusion in the study. A project and interviewee was identified if the following general criteria were met:

- The project manager had significant involvement in the startup planning process (typically this was the owner's project manager)
- The startup was completed within the last five years
- The total installed cost for the project exceeded $10 million
- The startup was, in the opinion of the interviewee, either very successful or very unsuccessful (average success or mediocre projects were intentionally avoided)

If these general selection criteria were met, a copy of the interview material was sent and an interview date set.

3.2.2 Project Interviews

Project interviews were conducted over an 18-month period. All interviews (with two exceptions) were conducted in the project manager's office by the same interviewer. All interviewees were either the owner's employees or

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had direct responsibility to the owner for startup operations, including introduction of raw materials. The goal of the research was to complete 30 project interviews. In total, 30 interviews were completed, of which 26 were considered complete. The 26 projects were from a total of 19 owner companies. Of the four interviews eliminated, two were the initial pilot interviews made with version 1 of the interview guide; one did not complete the follow-up success questionnaires, and one did not have a significant enough role in the startup to accurately complete the interview guide. After repeated unsuccessful attempts to complete or update these interviews they were eventually eliminated from the data set.

3.2.3 Database Development and Data Coding

The questionnaire data is a jumble of data formats including quantitative data, qualitative data and interviewer notes from the open-ended questions. For many questions, these data could be entered directly into the project database, but some responses required a data-coding step prior to data entry. Data coding procedures were developed based on the parameter being measured. They included the following:

- Project Phase: The coding follows a simple 1 through 8 numbering corresponding to the eight project phases.
- Satisfaction and Performance Levels: Measured using a numerical scale format with a 1 to 5 intensity scale. The higher the intensity, the higher the score.

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- Environmental and Safety: A "Yes" indicates violations of regulatory rules are scored as a "1": if the answer is "No", it is scored as a "5".
- Importance Factors: Measured using an intensity scale of 1 to 5. "Most Important" scored "5"; "Least Important" scored "1".

After the data was coded, it was entered into the database and extracted as required to develop various files that make up the project data set. The project database utilized the Microsoft Access 2.0 database software. A series of data entry forms were created to allow direct entry from the interview guide information into the database. After the data was entered and checked for accuracy data queries were made to develop data files for the project data set. The extracted data files were exported to either Microsoft Excel 97 or the statistical software package SPSS (Statistical Package for Social Science) for Windows Version 7.5 statistical analysis.

3.2.4 Statistical Considerations for the Sample Data Set

At the end of the data collection phase of the research, consideration was given to the statistical nature of the sample and its effect on meeting the objectives of the research. A summary of the conclusions is presented below:

- The data set is not a random sample of industry and is best described as a "convenience" sample.
- The data set does not include any projects where the basic technology was unproven resulting in facilities that were constructed but failed to startup.

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- Although it is biased toward CII companies, it may or may not be representative of CII or the process industry.
- The sample size is small (26) but the depth of information gathered increases it credibility and utility.
- While the sample size places some limits on the extent of any conclusions to be drawn, the sample is believed to be adequate to support the goals of the research and to validate CII's Planning for Start Model.

3.3 SUCCESS INDEXES AND SUPER TOOL DEVELOPMENT

An index is a summed composite of variables that are believed to reflect some underlying construct (Knoke and Bohrnstedt 1994). In this research three indexes were used including:

- The Startup Success Index (SSI)
- The Project Success Index (PSI) and
- The Startup Planning Evaluation Rating Tool (SuPER).

These indexes were extremely useful because they could be mathematically treated as continuous variables; and conceptually, they could be used as a quantitative means to measure something that could not be measured directly. The following is a discussion of how the indexes were computed.

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3.3.1 Startup Success Index

The Startup Success Index integrates eight startup success variables and serves as a proxy for the underlying construct “startup success”. This index was important to the research effort because it is the dependent variable in many of the statistical tests of the data set.

Development of the variables to be included in the Startup Success Index consisted of two-steps. Initially, a list of variables was identified by the Startup Research Team and then confirmed with the Interview Guide during the project interviews.

During the project interviews., the interviewee is asked to rate the importance of the Research Team's eight startup success variables and to add additional ones if necessary. In 24 interviews, all agreed that the eight variables were important and that none should be eliminated. (Note: the success questionnaire was developed based on these 24 interviews. Because the results were so unanimous, the remaining two interviewees were not asked this question.)

Eight of the 24 interviewee's suggested adding another term, "Startup Budget" to the list. This additional term was considered but dropped because of the paucity of reliable actual startup budget data. Although the startup budget was considered important to a significant portion of the interviewees, the reported accounting methods used for tracking these costs varied so widely from project to project that this metric was not useful.

The Startup Success Index was computed using the Performance and Importance scores from the Startup Success Questionnaire. Conceptually, the

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$$\text{Startup Success Index for Project} = \frac{\sum \text{Total Earned Points Score}}{\sum \text{Max.Possible Point Score}}$$

$$\text{Startup Success Index}_i = \frac{\sum_{n=1,k}^{k} \left(\text{Satifaction Score}_{i,j} \times \text{Importance Factor}_{i,j}\right)}{\sum_{n=1,k}^{k} \left(\text{Max Satisfaction Level Score}_j \times \text{Importance Factor}_{i,j}\right)}$$

where:
i = Project Number
j = Startup Success Criteria Number (See Questionnaire for Number)
k = Number of Success Criteria in Index

Startup Success Index is the ratio of the total points scored in each of the eight variables divided by the total possible points available. It is not based on a fixed number of points. Instead, a maximum possible point score is computed for each project based on the assigned importance factors and the maximum scale points for the startup success variables. This variable-points approach was adopted to account for the variance in startup objectives among the projects. The Startup Success Index is computed as follows.

The Total Earned Points Score is the summation of the product "Satisfaction Score times Importance Factor" for each index variable. The Max Possible Points Score is the summation of the product of "Max. Satisfaction Level Score" times "Importance Factor" for each index variable. The Max Satisfaction Level Score is the maximum point value assigned to the activity and was typically 5-points (See the Data Coding section in this chapter for a discussion of these

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values). Figure 3.3 shows an example of how the Startup Success Index calculation is made. A discussion of the startup success characteristics of the sample set is presented in Chapter 4.

3.3.2 Startup Success Index Weight Factors

Although the Startup Success Index adjusts weight factors to reflect project priorities, it is useful to exam the average and ranges of the weight factors to assess the relative importance of the eight success indicators. Figure 3.4 shows a boxplot of the weight factors and indicates that the median weight factors were approximately equal for all the indicators and were fairly evenly dispersed except for the indicator: Impact on On-going Operations. Table 3.1 summarizes the weight factor statistics.

Table 3.1 Average Weight factors for Startup Performance Indicators

Statistic	Performance Factor							
	Safety	Schedule	Product Quality	Product Quantity	Environ-mental	Ops. Team	LOE by SU Team	Impact on On-going Ops
Mean	0.143	0.137	0.136	0.126	0.125	0.118	0.115	0.100
Median	0.143	0.139	0.137	0.121	0.129	0.119	0.117	0.120
Min	0.067	0.077	0.088	0.063	0.067	0.080	0.067	0.000
Max	0.200	0.200	0.192	0.167	0.167	0.154	0.152	0.167

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Startup Success Criteria	Satisfaction and Importance Scores		Computed Scores	
	Satisfaction Score (a)	Importance Factor (b)	Earned Points Score (a * b)	Max. Possible Points Score (5 * b)
Product Quality	2	4	8	20
Product Quantity	2	4	8	20
Schedule Performance	2	5	10	25
Safety Performance	2	4	8	20
Environmental Performance	0	4	0	20
Operations Team Performance	1	4	4	20
Impact on Operations	2	5	10	25
Level of Effort	1	4	4	20
		Total	52	170

$$\text{Startup Success Index} = \frac{\text{Total Weighted Performance Score}}{\text{Total Max. Possible Score}}$$

$$= (52/170) \times 100$$

$$= 30.59 \text{ or } 31$$

Figure 3.3 Example Calculation for Computing Startup Success Index

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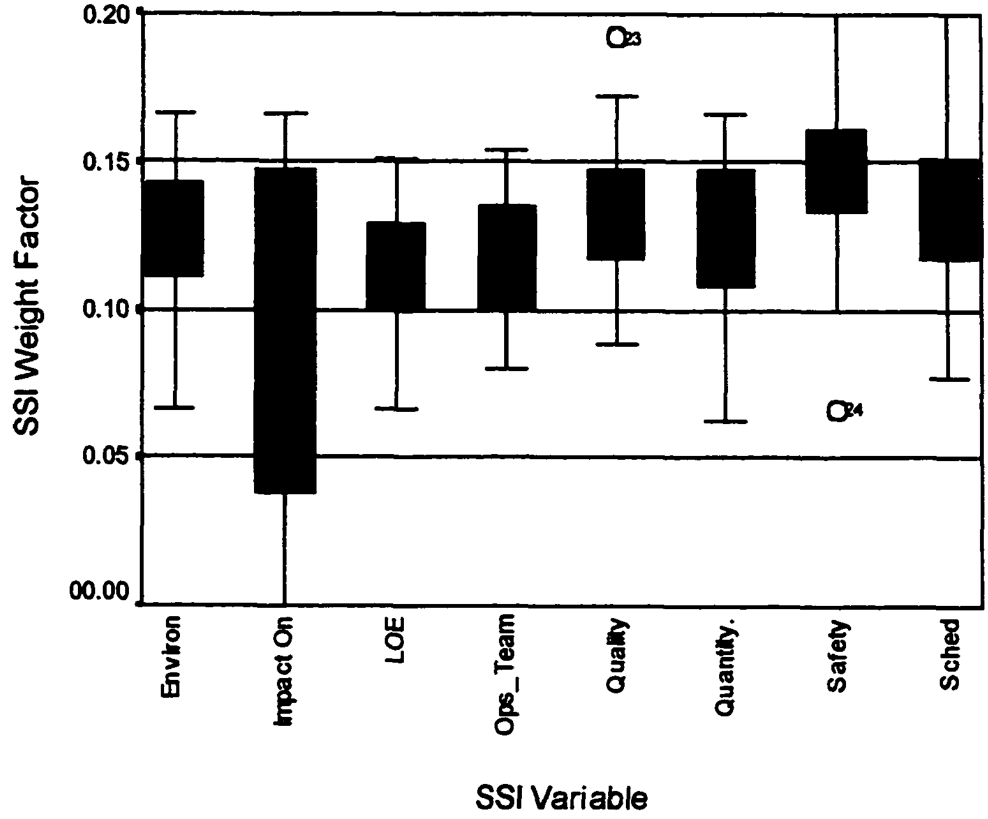

Figure 3.4 Distribution of SSI Weight Factors

Figure 3.5 shows a plot of the average weight factors indicating that on average, safety was the most important indicator and impact on on-going operations the least.

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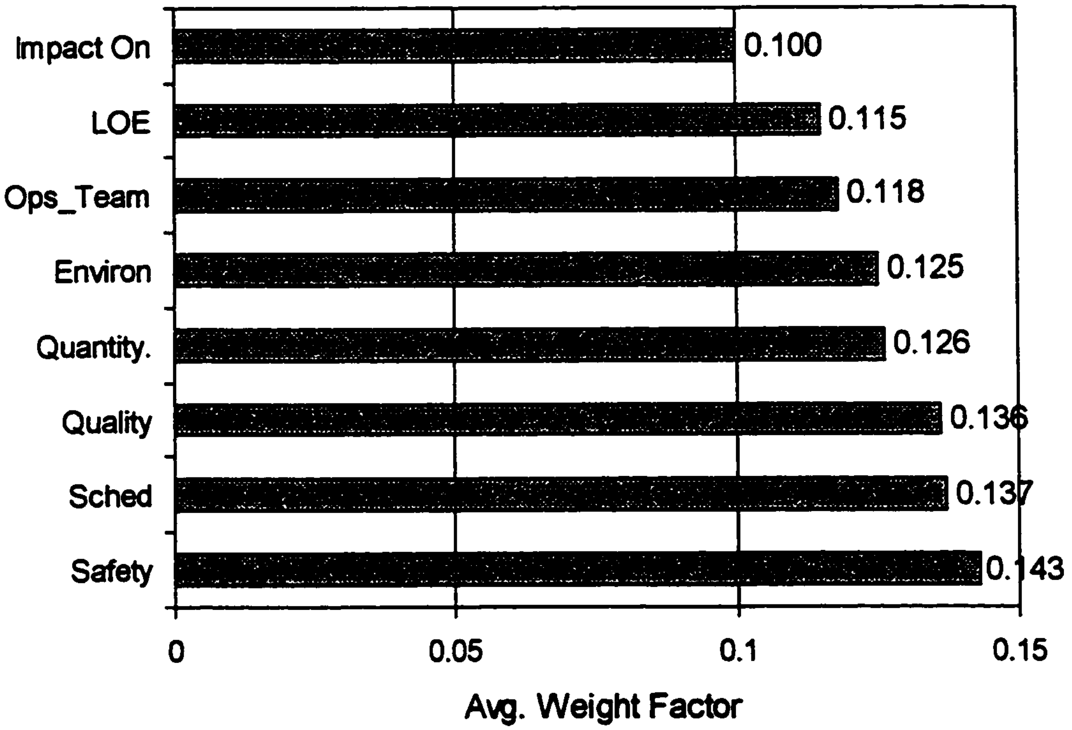

Figure 3.5 Ranking Startup Success Index Weight Factors

3.3.3 Reliability of the Startup Success Index

To assess the validity of the Startup Success Index two tests were conducted. In the first test, the level of *interrelationship* among the eight variables that make up the Startup Success Index was evaluated. Inherently, good indexes are highly interrelated and this interrelationship, also called the *reliability* of the index, can be tested using the Cronbach's alpha (α) statistic. A high alpha indicates a high level of inter-correlation, which gives confidence that the index

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items are measuring the same construct Knoke and Bohrnstedt (1994). Cronbach's alpha is computed as follows:

$$\alpha = \frac{k * r}{1 + (k - 1)r}$$

Where:

k = the number of indicators in the index
r = the average inter-correlation among the k index items

The computed alpha for the Startup Success Index was 0.71, which meets the acceptable alpha of 0.70 or higher reported by Knoke and Bohrnstedt (1994). The Cronbach alpha computation was performed using SPSS and the results are presented in Appendix B.

In the second test, the Startup Success Index and the Project Success Index data were paired and their relationship statistically tested. Because a successful startup is a component of a successful project, it is reasonable to expect that some relationship between the two exist. A discussion of the Project Success Index and its relationship to the Startup Success Index is presented in the next section.

3.3.4 Project Success Index

Project success and startup success is inter-related but not mutually exclusive. As such, there should be some reasonable (but not perfect) relationship between the two. To test this relationship a Project Success Index was created

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and then compared to the Startup Success Index. Evaluating the reasonableness of this relationship is useful to give credence to the Startup Success Index. The analysis also offers insight into how important startup success is to overall project success.

The Project Success Index was developed based in part on the research work of Gibson and Hamilton (1994) which developed and tested a four-variable, fixed weighting factor, Project Success Index. The current research has extended the four-variable index to a seven-variable index and added an adjustment step to take in account the project specific weighting factors for each variable. Using the average weight factors, the Project Success Index is computed as:

$$\begin{aligned}[\text{Proj Success Index}] \quad &= 0.16 * \text{Cost} + 0.16 * \text{Schedule} + 0.14 * \text{Capacity} + \\ &\quad 0.11 * \text{Down-time} + 0.17 * \text{Safety} + 0.14 * \text{Environ} + \\ &\quad 0.12 * \text{Operating Cost}\end{aligned}$$

The Project Success Index is computed in a manner similar to the Startup Success Index computations. It uses response data from the Project Success Questionnaire and incorporates the project specific importance factors for each success variable. Table 3.2 presents a comparison of the two indexes scores computed for each project.

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Table 3.2 Comparison of SSI and PSI Scores

Proj ID	Startup Success Index	Project Success Index	Proj ID	Startup Success Index	Project Success Index
P-03	11.6	28.7	P-18	12.7	20.3
P-04	84.6	49.0	P-19	74.4	21.8
P-06	65.1	60.2	P-20	73.6	83.6
P-08	54.7	77.4	P-21	14.2	20.1
P-09	57.8	60.2	P-22	54.1	41.1
P-10	83.1	60.7	P-23	64.0	41.8
P-11	36.0	39.5	P-24	67.2	68.3
P-12	66.2	74.2	P-25	55.8	54.5
P-13	35.2	39.9	P-26	43.7	36.0
P-14	72.8	87.5	P-27	83.2	49.6
P-15	18.9	20.6	P-28	42.7	38.2
P-16	82.5	58.9	P-29	9.4	18.4
P-17	100.0	32.8	P-30	61.9	45.4

The relationship between the proposed Startup Success Index and the Project Success Index is shown in figure 3.6. The scatterplot and regression analyses show a reasonable relationship between the two indexes.

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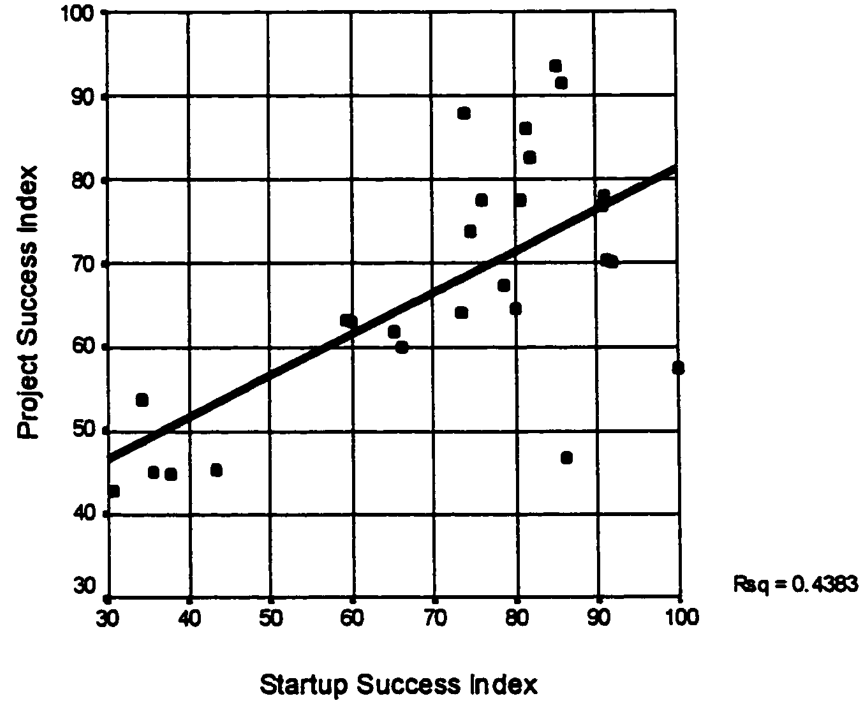

Figure 3.6 Startup Success Index vs. Project Success Index Regression

The R^2 of 0.43 is acceptable and understandable given the effect of the outlier projects at the upper ends of the scales. These outlier projects reinforce the belief that startup success is only one of several elements that contribute to project success. The t-statistic and related F-statistic are significant and support rejecting the null hypothesis that the regression coefficients are zero. Details of this regression analysis is presented in Appendix B

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3.3.5 Startup Planning Evaluation Rating Tool (SuPER)

Intuitively and within limits, the more one plans the greater likelihood of success. The issue is how to measure the degree or level of planning. Using a combination of data from the best startups; results from a full-scale startup demonstration project; and opinions from the CII Research Team 121, a tool -- the Startup Planning Evaluation Rating Tool (SuPER) -- was developed by the research team to measure level of startup planning (CII 1998; O'Connor et al. 1999). A copy of the tool is presented in Appendix B and a brief description of how the tool was used in this study is presented below.

The Level of Effort data from Section V of Interview Guide provides the data input for the SuPER scoring process. The interviewee effort data was transformed from the 0-5 effort scale to the SuPER Effort Categories using the coding scheme presented in table 3.3.

Table 3.3 Effort to SuPER Tool Coding Scheme

Interview Guide Planning Extent Score	SuPER Tool Rating
0	No Execution
1	Minimal Effort
2	Minimal Effort
3	With Deficiencies
4	With Minor Deficiencies
5	Thoroughly Executed

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The effort data was coded into SuPER scores and then entered into the project database.

3.4 DATA SET ANALYTICAL METHODS

The sample data were categorized then analyzed using a variety of statistical techniques including boxplots, multiple regression analysis, bivariate analysis, and significance testing. These analytical techniques are described below.

3.4.1 The Boxplot

The boxplot display of data is a useful tool for exploring the potential relationships between variables. It summarizes categories of data by plotting the median, the 25th percentile, the 75th percentile, extreme, and outlier values. Figure 3.7 shows an annotated sketch of a boxplot display (SPSS 1990).

The length of the box represents the interquartile range, which contains the 50% of values. A " * " or line across the box represents the median. Two types of outliers are shown in the boxplot. Cases with values that are more than three box-lengths from the upper or lower edge of the box are called extreme values. Cases with values that are between 1.5 and 3 box-lengths from the edge of the box are called outliers. Lines that extend from the box represent the range of highest and lowest non-outlier values.

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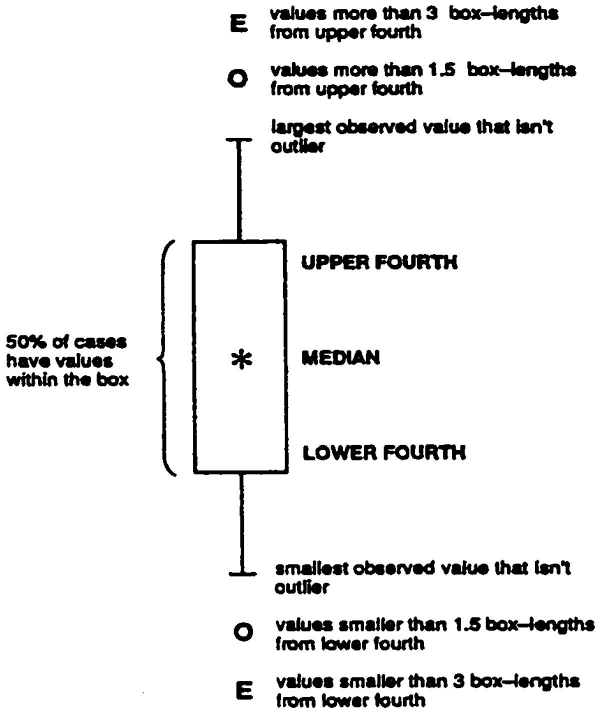

FIGURE 3.7 ANNOTATED SKETCH OF THE BOXPLOT

3.4.2 Multiple Regression Analysis

Multiple regression modeling was used to test the relationship between the Startup Success Index and selected variables from the data set. All regression modeling was performed using the statistical software packages SPSS for Windows Version 7.5 and Microsoft Excel 97. A discussion of the basic models used in these packages and the applicability of these assumptions to the data set follows.

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All of the regression models tested were structured in the format of the Classical Normal Linear Regression Model (CNLRM). This is the well-known linear regression model coupled with the expressed assumption that the error term is normally distributed. It is expressed mathematically as:

$$Y = \beta_i + \beta_2 * X_{2i} + \beta_3 * X_{3i} + ...+ \beta_k * X_{ki} + U_i$$

Where:
Y = Estimated Value of the Dependent Variable

β_i = Estimated Partial Regression Coefficient

X_i = Explanatory Variable or Regressor

U_i =Estimated Disturbance or Error Term

Note: In many statistical text it is common to denote the estimated coefficients, β_i, with a " ^ " or caret to designate it as a sample statistic which then can be used to infer a "true" population parameter. In this work, inference extends to the sample population only. Therefore, the " ^ " has been omitted.

The partial regression coefficients, the β's, were estimated using the method of Ordinary Least Squares (OLS). This method is considered to be a good estimator, in part, because: it is unbiased; it maximizes R^2; and, it is efficient (Kennedy 1996). Furthermore, the OLS computation methods are well developed and available in most statistical software, including SPSS and Excel.

Since the objective of the regression model is to estimate the partial regression coefficient as well as hypothesis testing, it is necessary to specify the probability distribution of the disturbance term U_i . OLS estimates of β are linear functions of U_i and therefore are directly affected by the assumptions made about

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the probability distribution of U_i. And since the probability distribution of β is necessary to draw inferences about its population values, the nature of the probability distribution of U_i assumes an important role in hypothesis testing (Gujarati 1995).

It is very convenient to assume these errors are normally distributed - but, is it true? There are several statistical tests for normality but the most intuitive approach is to evaluate the "Normal P-P plot" which compares the cumulative expected probability of the error term with the observed cumulative probability. An example of this plot using data from one regression run is presented in figure 3.8.

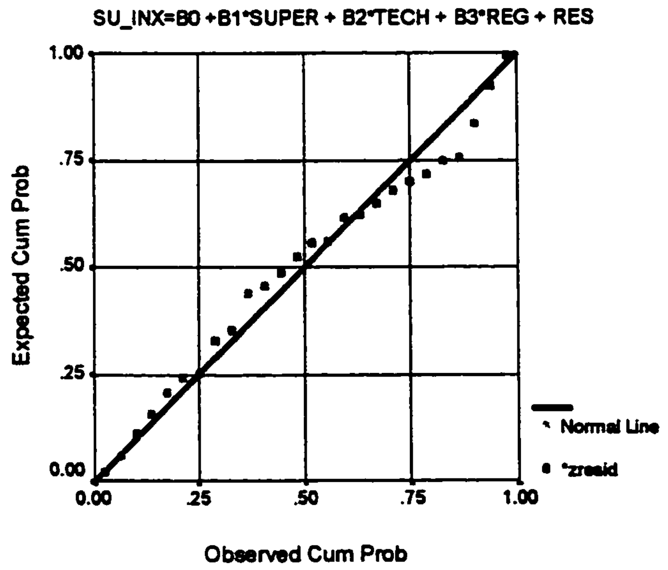

Figure 3.8 Normal P-P Plot of Regression Residuals

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The plot validates the assumption of normality because it shows acceptably close agreement between the expected error and the observed error under the normal distribution assumption.

3.4.3 Bivariate Analysis

The bivariate analysis uses a linear regression technique to assess the relationship among pairs of continuous variables. It was used to assess the relationship between individual planning activities in the Planning for Startup model and the Startup Success Index. The bivariate analysis was performed using the SPSS statistical software.

The strength of the bivariate linear relationship was used to indicate the contribution of an individual Planning for Startup model activity to startup success. The strength of the activities' contribution to the startup success index can be assessed by the strength of the linear relationship which is measured by the Pearson correlation coefficient, "r". The higher the absolute value of r, the stronger the relationship (SPSS 1990). The Pearson correlation coefficient is computed by the equation:

$$r = \frac{\sum_{i=1}^{n} (X_i - X_{avg})(Y_i - Y_{avg})}{(n - 1)S_x S_y}$$

Where:

r = Pearson Correlation Coefficient

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X_i = Effort or Phase Score for the Activity

Y_i = Startup Success Index

S_x = Standard Deviation of X

S_y = Standard Deviation of Y

The method assumes a continuous and linear relationship exists between the variables, and that they are normally distributed. The method is considered by statisticians to be robust. In other words, the conclusions regarding statistical significance are correct even if the assumptions regarding the probability distribution of the sample data set are violated Knoke and Bohrnstedt (1994).

3.4.4 Significance Testing

After the various models and coefficients were computed they were tested for statistical significance. Significance testing was applied to the following:

- The partial regression coefficients developed during the regression modeling
- The inter-correlation coefficients developed in the bivariate analysis
- The difference in categorical means between the "very successful" and the "very unsuccessful" startups

Significance testing followed the traditional approach of hypothesis testing outlined below (Freund 1992):

- Formulate the null hypothesis H_o and the alternative hypothesis H_A

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- Specify an acceptable level of significance (P value). Typically, a one-tail test with a 0.05 confidence level was used.
- Select a test statistic and the corresponding critical value. In this research it was either the F-statistic or the Student's t-statistic.
- Compute the test statistics using SPSS or Excel
- Compare the test statistic with the critical statistic and, accordingly reject the null hypothesis or accept it

This concludes the discussion of the methods used to develop the various survey instruments, identification of the sample projects, data collection and coding, and statistical methods for data analysis. In the following chapter, the characteristics of the interview data and its descriptive statistics are presented.

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Chapter 4 Interview Results and Study Variables

In this chapter the characteristic of the projects and the perspectives of the interviewees are described. The objectives are to describe the data set to support the applicability of the research to a wide range of process industry types; and, to convey an understanding of the variables used in the various statistical analyses presented in Chapters 5 and 6.

The interview results are summarized by two broad categories. The first is Project Characteristics, which summarizes the interviewee's background and the attributes of the project. The second category, Startup Characteristics, focuses on the startup aspects of the projects and includes summarizes of the startup success index data and startup planning data.

4.1 PROJECT CHARACTERISTICS

In this section the various characteristics of the project comprising the sample data set are described. Initially, summaries of interviewee characteristics are presented, which include project role, company affiliation, and number of years of project experience. Descriptive statistics of the sample projects are then presented that include industry type, project size, site conditions, construction contracting methods, process technology, and the regulatory environment of the project.

The data set contains twenty-six projects. Twenty-five are private sector projects; the remaining one is a joint, private/public sports authority project. All

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of the projects were completed during the period 1986 - 1997. Twenty-four were completed in the United States, and one each in Canada and the United Kingdom.

4.1.1 Interviewee Information

The majority of the interviewees were affiliated with the owner and served as the project manager for the project. Figures 4.1 and 4.2 show the interviewee's role and company affiliation. The majority, 73%, were the project manager; four, or 15%, were the startup manager; and one served as both the project manager and startup manager. The remaining two interviewees were senior management representing the owner's Vice-President of Plant Maintenance and the owner's Manager of Engineering. All of the interviewees had detailed knowledge of the project and the startup planning effort.

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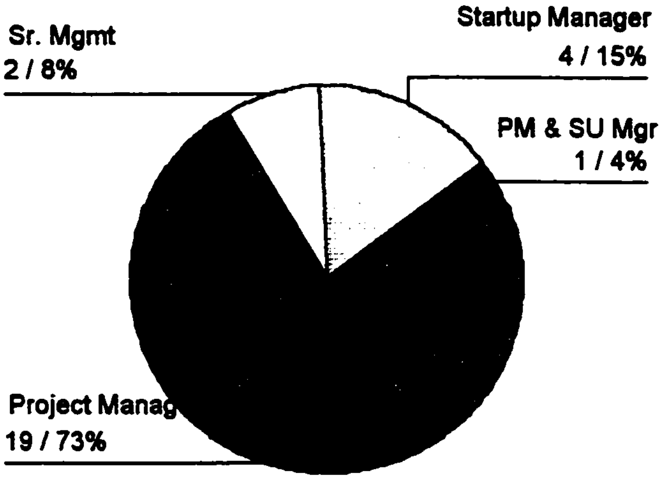

Figure 4.1 Role of Interviewee in Project

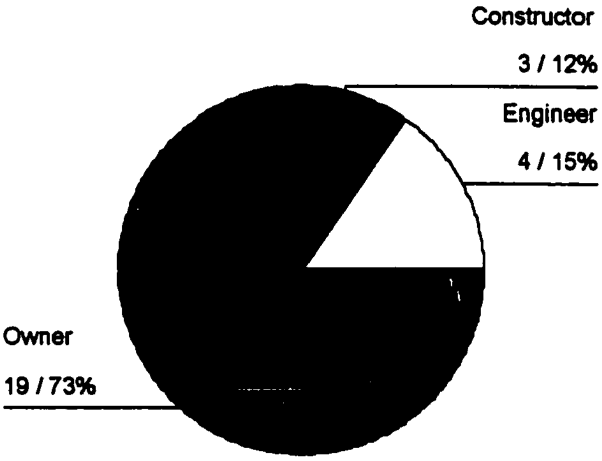

Figure 4.2 Affiliation of Interviewee

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4.1.2 Years of Experience

The interviewee's work experience ranged from nine to 40 years and averaged over 21 years of experience. The median experience level was also approximately 21 years.

4.1.3 Industry Type

Figure 4.3 presents a break down of the sample data by industry type. The largest sector is the chemical industry with 10 projects, or 36%, followed by the pharmaceuticals industry with five, or 19%. Food, power, and metals industries follow with two projects each. Pulp and paper, building, and semiconductor-manufacturing industries are represented by one project each.

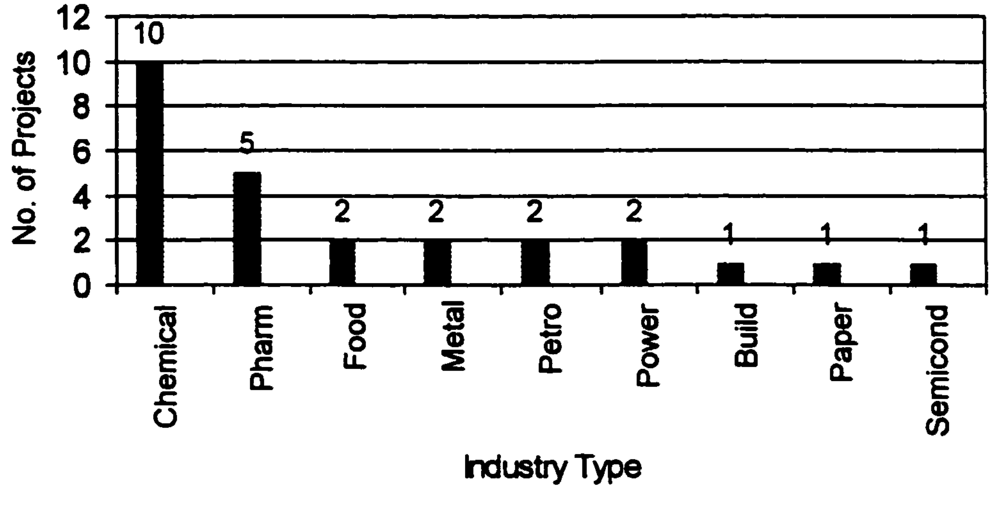

Figure 4.3 Industry Types in Project Sample

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Sample projects are categorized based on the company's industry segment, which may or may not be directly related to production of a saleable product. For example, an industrial wastewater treatment plant at a large chemical production facility is categorized as a chemical project because it is done within the chemical industry and therefore reflects the planning and management characteristics of that industry segment.

4.1.4 Project Size

Figure 4.4 shows the distribution of the sample projects cost. The size or total installed cost (TIC) of the sample projects ranged from $6 MM (million) to

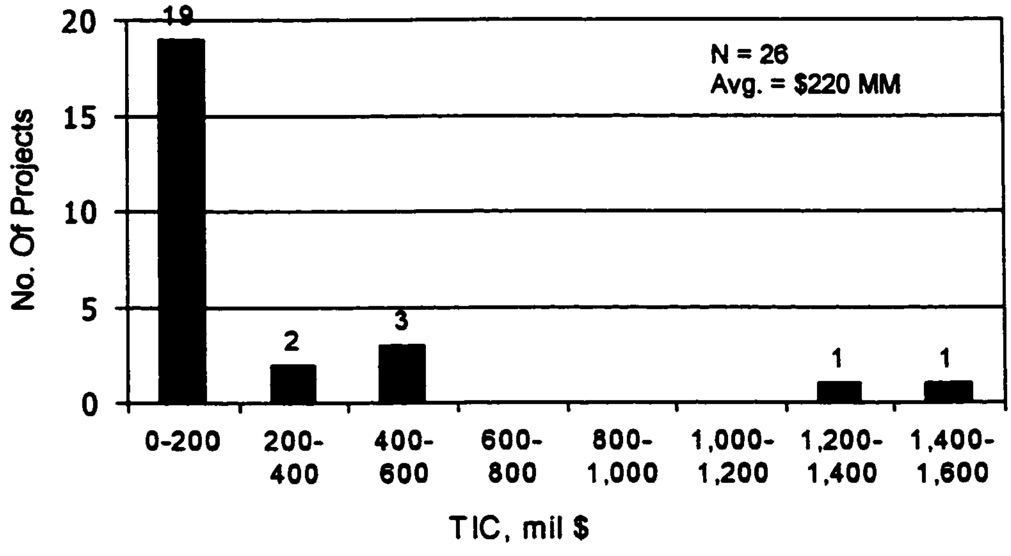

Figure 4.4 Sample Project Size

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$1,500 MM. Combined, these projects had a total installed cost of approximately $5.7 billion dollars and an average size of $220 MM dollars. The median project size was $75 MM dollars.

Figure 4.4 including two multi-billion dollar projects, P-04 and P-22 which distorts the distribution of the plot. When these outlier projects are omitted, the average project size is reduced by $94 MM dollars to approximately $126 MM dollars. Figure 4.5 shows the cost distribution with those extreme projects omitted.

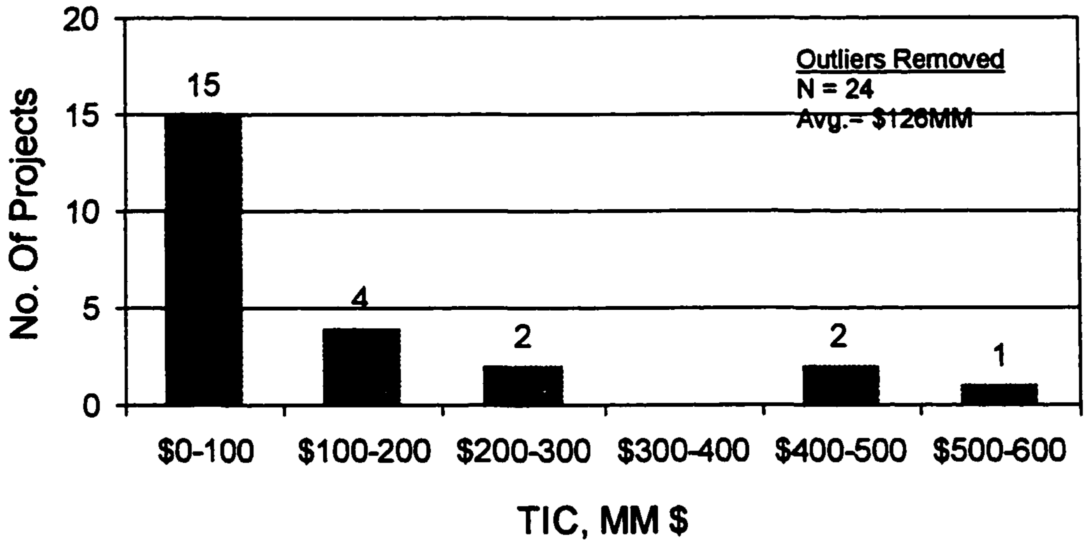

Figure 4.5 Sample Project Size without Outliers

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4.1.5 Site Conditions

All of the projects in the sample were constructed in the industrialized countries of the United States, Canada and the United Kingdom; none were constructed in remote locations that required the construction of separate labor camps. Previous studies have shown that global location and site remoteness have a significant effect on the project outcome (Merrow 1988). By eliminating these effects, site condition effects were reduced to two categories: grass roots or retrofit. Figure 4.6 presents a breakdown of the types of construction sites in the sample.

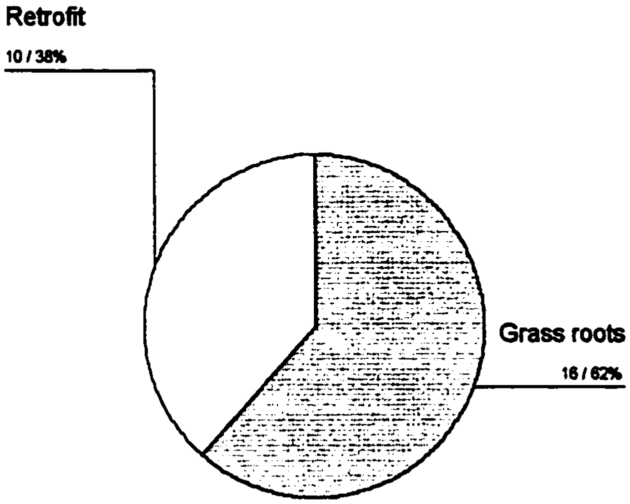

Figure 4.6 Summary of Site Construction Conditions

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The majority, 62%, of the projects were classified as grass roots. A grass root site is defined as a new plant site or, an undeveloped site located within an existing production complex. The remaining 38% were retrofit site projects, which are defined as upgrade or de-bottlenecking projects constructed within an existing facility. Projects that were classified as maintenance/retrofit were included in the retrofit definition and were not differentiated.

4.1.6 Construction Contracting Methods

The survey collected two types of construction contracting information. One was the payment portion, which was defined as "Lump Sum" or "Cost Plus". The other was related to the number on contracts used by the owner to execute the project. If one contract was used, the project was defined as an "EPC" (Engineering, Procurement and Construction) project. If the owner executed numerous contracts, it was defined as a "multiple contract" project. Figure 4.6 shows the breakdown of the contracting methods used for the projects in the data set.

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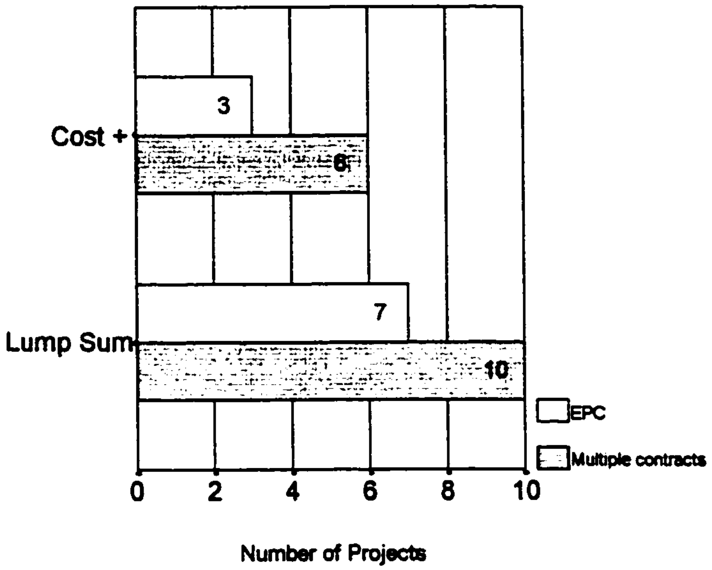

Figure 4.7 Contract Payment Terms

4.1.7 Manufacturing Process Technology Maturity

Process knowledge or "experience factor" is one of the more cited assets necessary for conducting a successful startup (Myers et al. 1986; Merrow 1988; Feldman 1969). Realistically, every new project has some element of new or unproven technology, so it is not merely the presence of new technology that is important to the outcome of the startup but the relative amount as well.

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In this study the level of process technology was broadly defined as either new or mature. A new technology is one for which there is minimal previous experience within the project organization. For example, a natural gas-fired, steam electric power generating plant is considered a mature technology project; but, if the fuel system was modified to a waste-coal-fired system, and the project team has no experience with this process it was classified as a new technology project. Figure 4.8 shows the distribution of technology types (and industry sector) for the sample projects. Overall, the majority, 15 of 26, of projects were classified as new technology, the remaining 11 projects were classified as mature

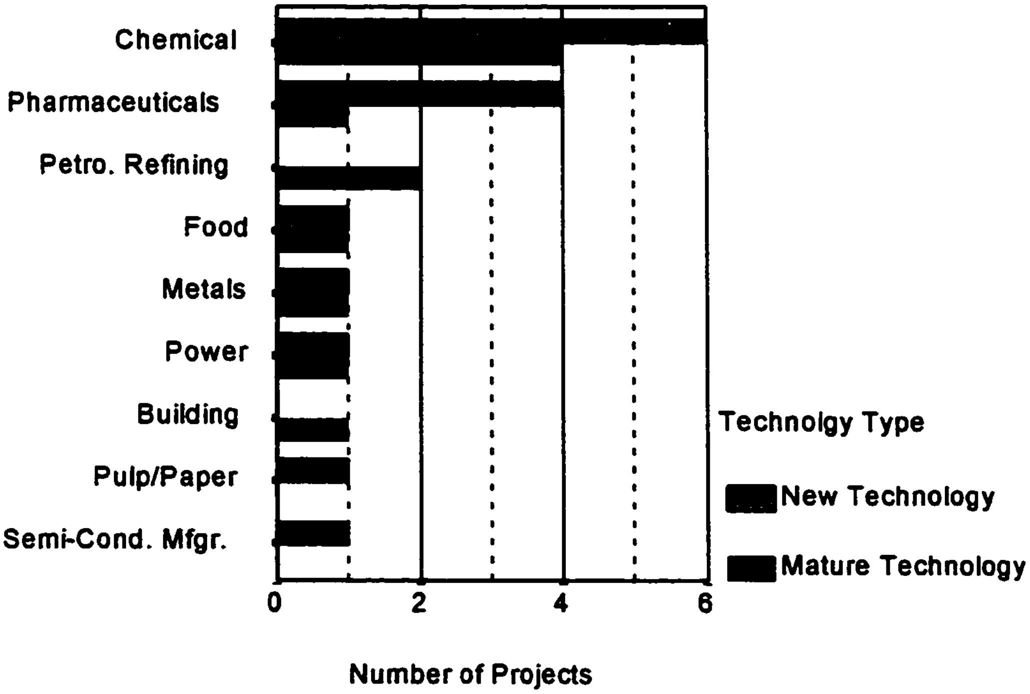

Figure 4.8 Sample Technology Types

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technology. The majority, 10 of 15, of the new technology projects were confined to two industries: chemical and pharmaceutical.

4.1.8 Regulatory Environment

Project characteristics and interviewees history provide useful information on the internal landscape of the project team environment, but give little insight into the external macro-level factors, such as the project's social, regulatory and labor settings, that can affect the ultimate success of a project.

In this study there were no formal questions on external factors. However, reliable information regarding their presence and effects could be gleaned from interviewee responses to the open-ended interview questions. Using these responses, projects were categorized as having an external factor if it met any or all of the following three criteria:

External Factor Determination Criteria

1. External factors were mentioned as a causal factor for the project or startup successes.
2. The justification or driver for the project was to achieve compliance with a regulatory requirement.
3. The project owner was a governmental agency.

The fact that a company is regulated does not justify categorizing the project as externally affected. For example, in the pharmaceutical industry production is highly regulated and company processes are geared to meeting these

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regulatory requirements. However, these projects were not categorized as projects with external factors unless they were driven by some additional external factor such as the pharmaceutical waste disposal project P-18.

Seven projects in the sample set were categorized as having significant external factors. These projects represent a broad range of industry types and conditions for inclusion in the category. External factors affecting the projects in the sample included labor unrest, construction of a politically charged project, and construction of projects for environmental compliance.

Table 4.1 summarizes the projects with significant external factors. The sample was nearly evenly divided, four projects used new technology and three relied on mature ones. There was no apparent relationship between process technology and external factors.

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Table 4.1 Summary of Projects with External Factors

Project ID	Industry Type	Type of Project Externality	Tech. Type	Startup Success Index
P-03	Chemical	Environmental regulatory project required for wastewater discharge permit.	New	34
P-06	Petro. Refining	Project for Federal government	Mature	81
P-11	Building	The owner is a quasi-governmental sports authority.	Mature	60
P-13	Food	Facility required rabbinical certification of conformance with food handing rules	Mature	59
P-18	Pharmaceutical	Environmental project required for destruction of medical wastes from plant production	New	36
P-21	Chemical	Incinerator project required for operating permit. After explosion of incinerator air permit problems delayed project 4-6 months	New	38
P-29	Pulp/paper	Serious problems with organized labor. Entire project affected.	New	31

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4.2 STARTUP CHARACTERISTICS

4.2.1 Startup Success

Figure 4.9 presents the frequency distribution of the Startup Success Index scores for the projects in the sample. The distribution appears to be bimodal with an unbalanced tendency toward the upper end of the Startup Success Index scale. Descriptive statistics for the Startup Success Index values are presented in table 4.2.

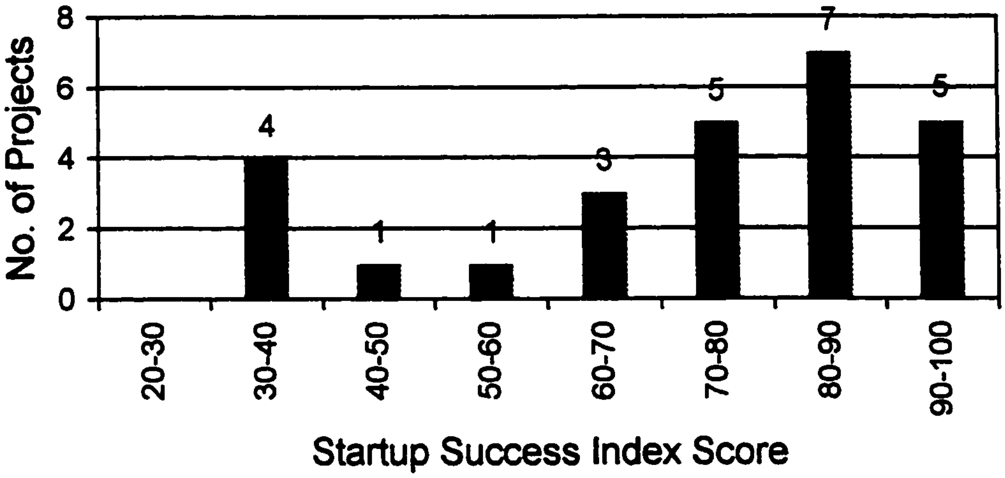

Figure 4.9 Frequency Distribution of Startup Success Index

The statistics show Startup Success Index ranging from a low of 31 to a high of a perfect 100. The mean and median values, 71 and 76 respectively, are high, which is consistent with a sample population that is skewed toward

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successful startups. These biases reflect the intent of the research plan to sample projects with either "very successful" or "very unsuccessful" startups. To further explain and relate the Startup Success Index score with the interviewee's comments a summary of the of the interviewee's comments on the success or failure of the startup is presented in Appendix C

Table 4.2 Summary Statistics for Startup Index

Descriptives

			Statistic	Std. Error
SSI	Mean		70.58	4.01
	95% Confidence Interval for Mean	Lower Bound	62.30	
		Upper Bound	78.87	
	Median		76.00	
	Variance		402.90	
	Std. Deviation		20.07	
	Minimum		30.59	
	Maximum		100.00	
	Range		69.41	
	Skewness		-.81	.46
	Kurtosis		-.42	.90

4.2.2 Categories of Startup Success

In order to explore the characteristics of the extremes, the Startup Success Index data were further segregated into "very unsuccessful", "very successful" and “moderate performance” startups. Using the frequency distribution as a guide, projects with Startup Success Index values in the upper and lower ends of the data set were classified as "very successful" or "very unsuccessful". These classifications represent the approximate upper and lower 20% percentile of the sample set. A histogram overlain with the 10 projects that make up the Very

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Successful and Very Unsuccessful success categories is presented in Figure 4.10. A histogram of the categorized dataset is presented in Figure 4.11.

The category criteria were developed to achieve the following objectives: 1) the sub-sample sets should include only projects from the "very" edges of the sample-set distribution curve; and 2) the sub-sample sets should have an equal number of projects in each success category. The later criterion attempts to equilibrate the variance in the two sub-groups (Freund 1992).

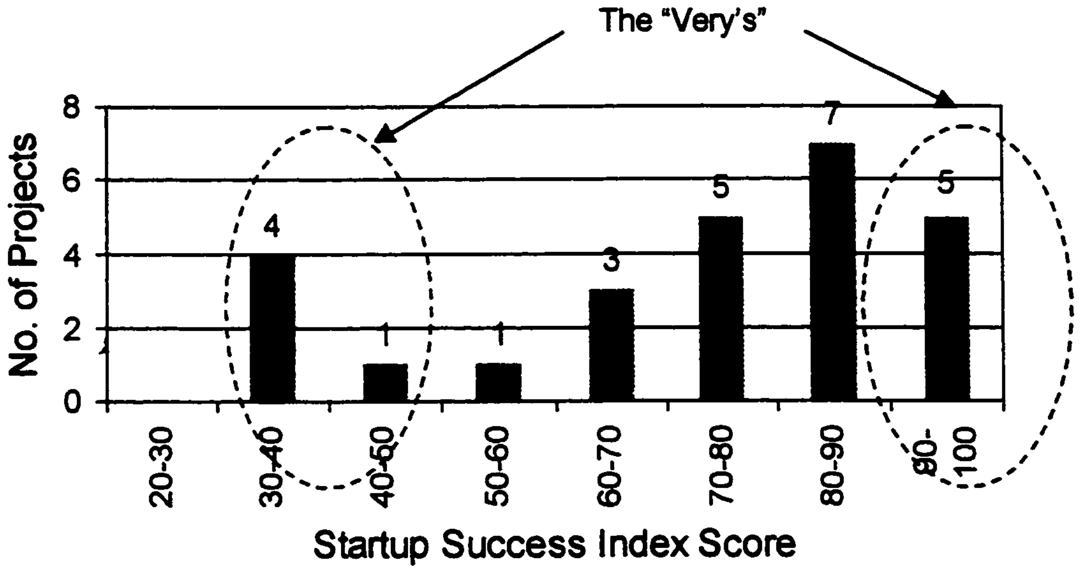

Figure 4.10 Categories of Startup Success

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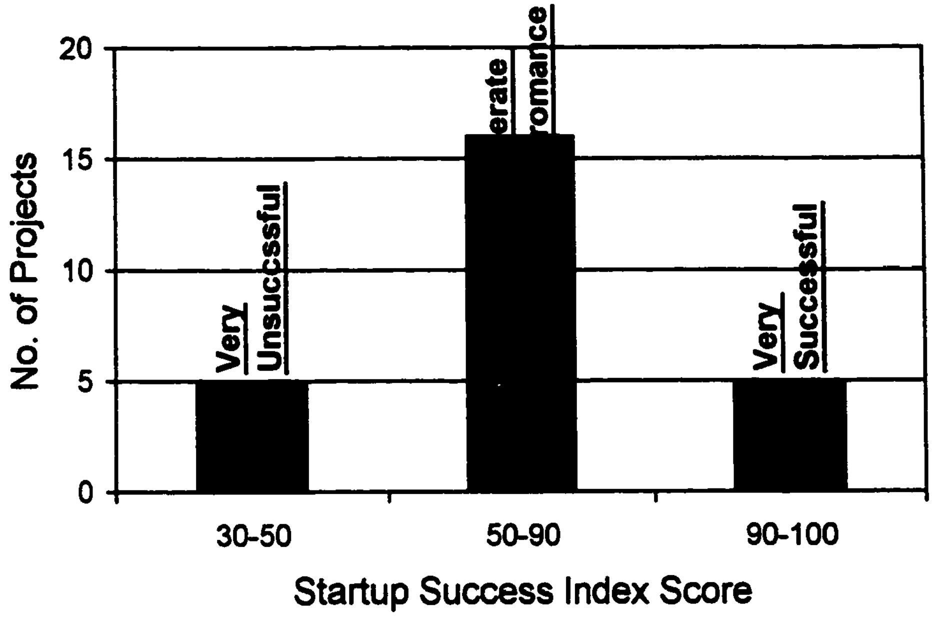

Figure 4.11 Categorized Startup Success Data

Table 4.3 summarizes the results of the categorization process. A "very successful" startup is defined as a project with a Startup Success Index score of 91 and above; conversely, a "very unsuccessful" startup is defined as a project with a Startup Success Index score of 41 and below. A total of ten projects were selected; five projects from the upper and lower ends of the sample data set.

Table 4.3 Summary of Startup Success Categorizations

Success Class	Startup Success Index Score	Percentile of Sample	Projects ID
Very Successful Startup	≥ 91	Upper 19%	P-04, -10,-16, -17, -27
Very Unsuccessful Startup	≤ 41	Lower 19%	P-03, -15, -18, -21, -29

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Box plots of the three success categories are presented in figure 4.12 and show the category groupings to be closely aggregated, with a wide gap between the median Startup Success Index values for the "very successful" and "very unsuccessful" startups. These visual differences are statistically confirmed by the descriptive statistics presented in table 4.4.

Table 4.4 Descriptive Statistics of Success Categories

	Category		Statistic	Std. Error
SSI	V. Unsuccessful	Mean	.36	.021
		Median	.36	
		Std. Deviation	.05	
		Minimum	.31	
		Maximum	.43	
		Range	.13	
	Mod. Performance	Mean	.76	.022
		Median	.77	
		Std. Deviation	.09	
		Minimum	.59	
		Maximum	.86	
		Range	.27	
	V. Sucessful	Mean	.93	.018
		Median	.91	
		Std. Deviation	.04	
		Minimum	.91	
		Maximum	1.00	
		Range	.09	

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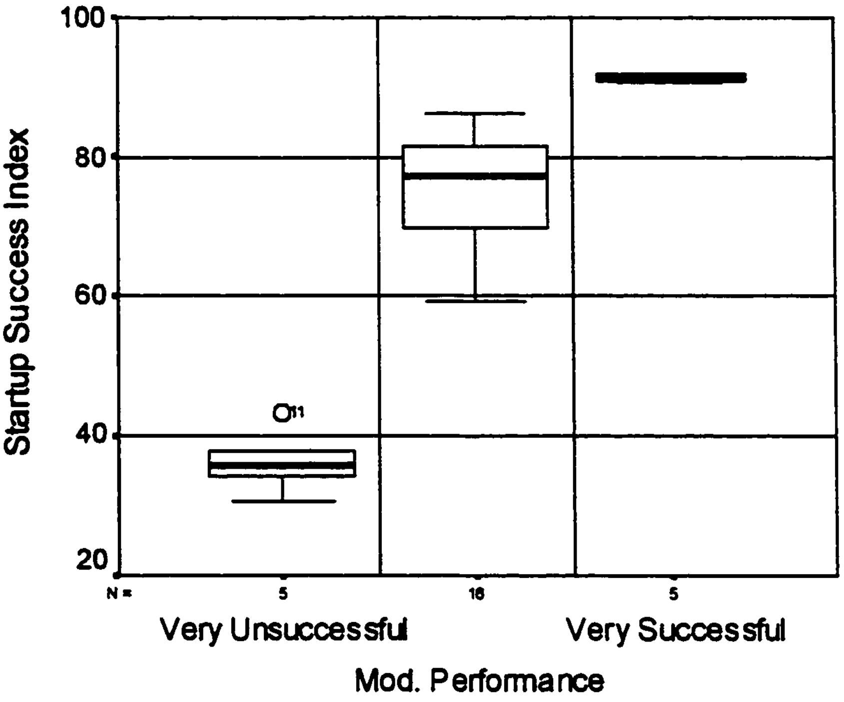
Figure 4-12 Box Plot of Startup Success Categories



Graphically there is a large difference between the "very successful" and "very unsuccessful" startups. To test the significance of this difference, a paired difference test between the two categories was conducted. The results, presented in table 4.5, indicate that with a confidence level exceeding 99.9%, these differences are significant.

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Table 4.5 Significance Test Results for Success Categories

	V. Successful	V. Unsuccessful
Mean	93.0	36.3
Variance	0.002	0.002
Observations	5	5
Pearson Correlation	0.158	
Hypothesized Mean Difference	0.000	
Df	4.000	
t Stat	22.294	
P(T<=t) one-tail	0.00001	
t Critical one-tail	2.132	

4.2.3 Characteristics of Selected Startups

As a check of the selection methodology, Tables 4.6 and 4.7 provide a qualitative comparison of the properties of the selected startups.

Table 4.6 Characteristics of "Very Successful" Startups

Project-ID	SU Success Index	SuPER Score	Process Technology	Externalities Present?
P-04	92	85	Mature	No
P-10	91	65	Mature	No
P-16	91	86	Mature	No
P-17	100	89	Mature	No
P-27	91	98	New	No
Mean	**93**	**85**	**Mature (4/5)**	**No**

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Table 4.7 Characteristics of "Very Unsuccessful" Startups

Project ID	SU Index	SuPER Score	Process Technology	Externalities Present?
P-03	34	85	New	Yes
P-15	43	51	New	No
P-18	36	38	New	Yes
P-21	38	80	New	Yes
P-29	31	75	New	Yes
Mean	**36**	**66**	**New**	**Yes (4/5)**

The results are as expected. The "very successful" startups had high Startup Success Indexes and SuPER scores, most (4 of 5) have mature process technologies, and none experienced significant effects of regulatory externalities. The reverse condition is seen in the "very unsuccessful" startups. All of these projects had low Startup Success Indexes and SuPER scores, all employed new technologies, and most (4 of 5) had significant external effects.

4.2.4 Startup Planning Effort

The level of the startup planning effort for each of the sample projects is discussed in the context of the SuPER score, an index developed by the Startup Research Team to quantitatively indicate the degree of model implementation. SuPER scores for each project were computed using the SuPER tool scoring sheet

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and startup planning data from Section V of the Interview Guide. (For a discussion of the SuPER tool see Chapter 3)

The SuPER score descriptive statistics and frequency distribution for the sample projects are presented in table 4.8 and figure 4.13 respectively. The SuPER scores range from a low of 38 to a near-perfect score of 98. The average and median data indicate a relatively high level of model implementation.

The SuPER score data was further categorized using the Super Score definitions and ranges shown in table 4.9. The ranges were developed such that

Table 4.8 Descriptive Statistics of SuPER Score Results

		Stat Type	
	Statistics	Statistic	Std. Error
SUPER	Mean	72.58	2.96
	Median	75.80	
	Std. Deviation	15.10	
	Minimum	37.80	
	Maximum	97.60	
	Range	59.80	
	Skewness	-.50	.46
	Kurtosis	-.41	.89

the scores were approximately uniformly distributed about the "With Deficiencies" Category, and the mid-point of the range approximated the

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"Maximum Total: All Phases " score from the SuPER tool form (See Appendix B for a listing of the values). The categorized data are presented in figure 4.14. The

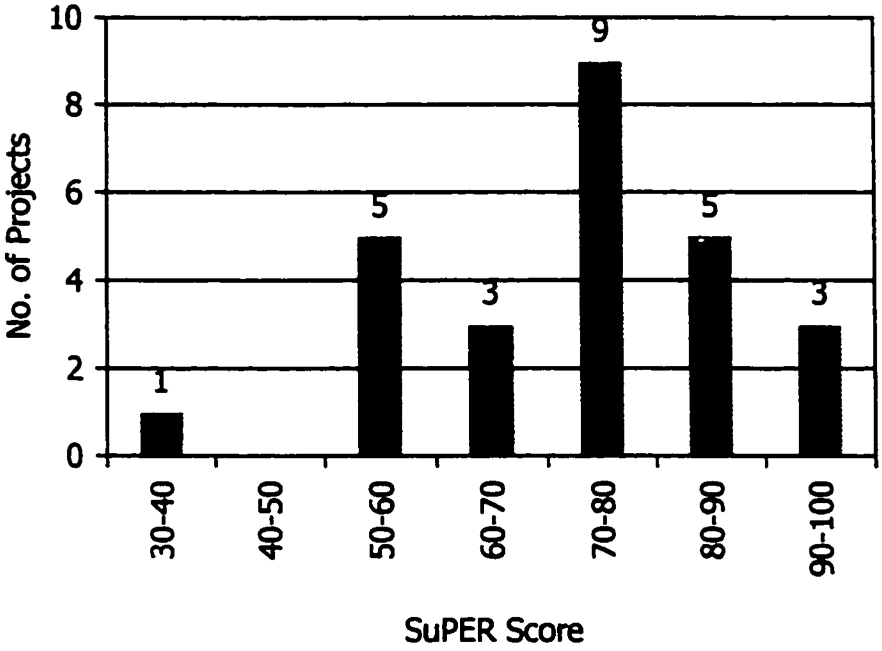

Figure 4.13 Distribution of SuPER Scores in Sample

plot shows the Planning for Startup model was "Thoroughly Executed" or "Executed with Minor Deficiencies" in approximately 65% (17 of 26) of the projects.

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Table 4.9 SuPER Score Categories of Model Implementation

Definition of SuPER Score Ranges	SuPER Score Range
0 ≤ "No Execution < 10	10
10 ≤ "Min. Effort < 30	20
30 ≤ "w/ Deficiencies < 70	40
70 ≤ "Minor Deficiencies < 90	20
90 ≤ "Thoroughly Executed ≤ 100	10

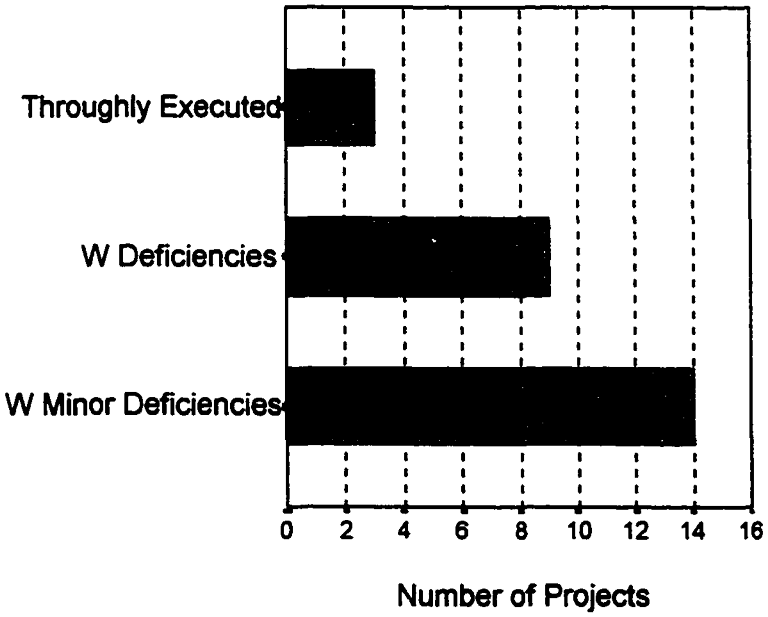

Figure 4.14 Categories of Model Implementation

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4.2.5 Startup Responsibility

Startup responsibility is overwhelmingly--but not exclusively--the owner's responsibility. As shown in figure 4.15, 19 of the 26 startups were lead by a manager that was affiliated with the owner; the remaining seven were lead by a startup manager affiliated with the engineer or constructor. Industry types for these non-owner startups were from the power, food and building industries.

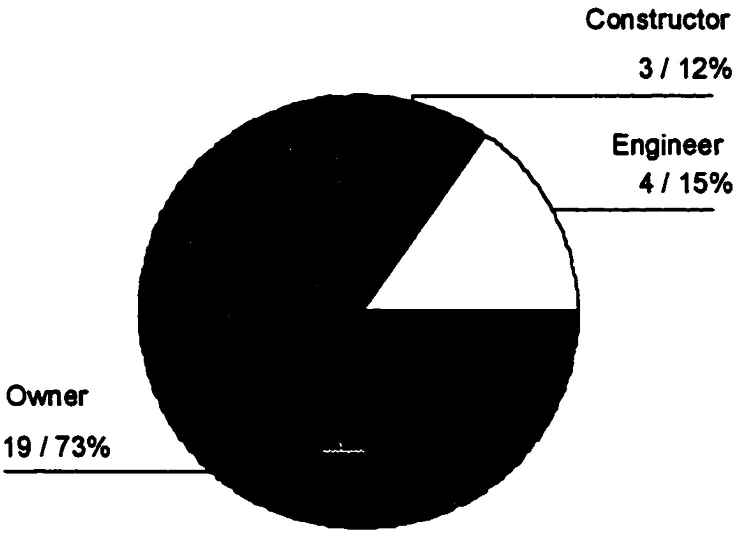

Figure 4.15 Affiliation of Startup Manager

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4.3 SUMMARY CHARACTERISTICS OF THE DATA SET

A summary of the data set characteristics reported in the chapter is presented in table 4.10. For clarity, the data is sorted in order of the Startup Success Index with the most successful startups presented first. General characteristic of each of the data attributes are summarized below:

- Number of Projects: 26
- Industry Type. Primarily chemical and pharmaceutical industries. A total of nine industry groups are represented with the majority (57%) from the chemical and pharmaceutical industries.
- Startup Success. The startups were relatively successful. The "average project" had a startup success index of 71 (out of a possible 100). Two sub-populations of startups, "Very Successful" and "Very Unsuccessful" were identified and represent, approximately, the upper and lower 20% of the sample with five project each. The shaded area in the table identifies these upper and lower percentile projects.
- Startup Planning. The level of startup planning, as measured by the SuPER tool score, averaged 73 points indicating a relatively high level of model implementation.
- PM Years of Experience. An experienced group of engineers with a sample average of 21 years of industry experience.

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Table 4.10 Summary of Project Characteristics [1]

Project ID	Industry Type	SU Success Index	SuPER Tool Score	PM Experience, Yrs.	TIC, MM $	Process Tech.	Construction Site	External Factors
P-17	Chemical	100	89	26	$550	Mature	Grass roots	No
P-04	Power	92	85.1	22	$1,200	Mature	Grass roots	No
P-10	Chemical	91	64.9	21	$13	Mature	Retrofit	No
P-16	Petro. Ref.[2]	91	85.7	17	$250	Mature	Retrofit	No
P-27	Pharm.[3]	91	97.6	14	$160	New	Retrofit	No
P-19	Pharm.	86	65.8	18	$30	New	Retrofit	No
P-20	Chemical	86	87.8	30	$490	Mature	Grass roots	No
P-14	Metals	85	91.5	28	$80	Mature	Retrofit	No
P-24	Chemical	82	79.3	17	$57	New	Grass roots	No

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Table 4.10 - Continued

Project ID	Industry Type	SU Success Index	SuPER Tool Score	PM Experience, Yrs.	TIC, MM $	Process Tech.	Construction Site	External Factors
P-06	Petro. Ref.	81	54.7	18	$43	Mature	Grass roots	Yes
P-12	Food	81	76.3	10	$30	New	Grass roots	No
P-23	Chemical	80	78	30	$50	New	Grass roots	No
P-30	Chemical	79	57	16	$13	Mature	Retrofit	No
P-09	Power	76	70.5	22	$70	New	Grass roots	No
P-25	Chemical	75	74.4	16	$14	New	Retrofit	No
P-08	Chemical	74	90.6	24	$150	New	Grass roots	No
P-22	Mfgr.[4]	74	70.7	9	$1,500	New	Grass roots	No
P-26	Pharm.	66	50	13	$88	New	Grass roots	No
P-28	Pharm.	65	53.7	12	$6	Mature	Retrofit	No
P-11	Building	60	79.2	23	$42	Mature	Grass roots	Yes
P-13	Food	59	62	30	$7	Mature	Retrofit	Yes

Table 4.10 - Continued

Project ID	Industry Type	SU Success Index	SuPER Tool Score	PM Experience, Yrs.	TIC, MM $	Process Tech.	Construction Site	External Factors
P-15	Metals	43	51.2	40	$200	New	Grass roots	No
P-21	Chemical	38	80	13	$115	New	Grass roots	Yes
P-18	Pharm.	36	37.8	30	$17	New	Grass roots	Yes
P-03	Chemical	34	79	25	$130	New	Grass roots	Yes
P-29	Pulp/Paper	31	75.3	35	$425	New	Retrofit	Yes

Notes:

1. Projects Sorted in order of decreasing Startup Success Index.
2. Pharmaceutical
3. Petroleum Refining
4. Manufacturing
5. Shaded area indicates "Very Successful" or "Very Unsuccessful Startup"

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- Project Cost. Overall, the average cost of the projects was approximately $220 millions. However, this average is misleading because it is skewed by the presence of two multi-billion dollar projects. When these large projects are removed, the average project size is $126 millions.
- Process Technology. The sample was well represented by both new (57%) and mature (43%) process technologies.
- Construction Site. Approximately two-thirds (62%) of the projects were constructed on grass-roots sites.
- External Factors. Most of the projects (73%) reported no significant or unusual level of regulatory, social or environmental external factors.

This concludes the discussion of the projects included in the sample. In the following chapters these data are analyzed using a variety of statistical techniques to assess their role in contributing to the success of a project startup.

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Chapter 5 Multiple Regression Analysis of Startup Success Models

This chapter presents the results of the multiple regression analysis of the relationship between the Startup Success Index (the dependent variable), and seven project characteristics (the independent variables). The computed regression coefficients and statistics are reported and tested to determine the significance of these characteristics in contributing to startup success.

5.1 CONCEPTUAL MODEL

The conceptual model of Startup Success assumes there is a linear and statistically significant relationship between the dependent variable Startup Success Index (a measure of the level of startup success) and the independent variables of:

1) The level of startup planning;
2) The total installed cost of the project in million dollars;
3) The logarithm (log) of the total installed cost;
4) The type of construction site;
5) The level of technology development;
6) The years of project management experience; and
7) The effect of excess regulatory externalities.

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The proposed Startup Success Model is expressed mathematically as:

$$
\begin{aligned}
[\text{Startup Success Index}] = \beta_0 + \beta_1 * [\text{SUPER Score}] &+ \\
\beta_2 * [\text{TIC}] &+ \\
\beta_3 * [\text{YEARS}] &+ \\
\beta_4 * [D_{\text{TECH}}] &+ \\
\beta_5 * [D_{\text{SITE}}] &+ \\
\beta_6 * [D_{\text{REG}}]&
\end{aligned}
$$

Where:

SUPER Score = the level of **startup planning**

TIC = the total installed **cost** of the project

YEARS = the project manager's years of **experience**

D_{TECH} = Technology Type Code: 1 for Mature technologies/ 0 for New Technologies

D_{SITE} = Site Type Code: 1 for Retrofit at Existing Site/ 0 for Grass-Roots Site

D_{REG} = Regulatory Effect Code: 1 for Significant Level of Externalities/ 0 for Expected Levels of Externalities.

β_i = Computed Partial Regression Coefficient for variable *i*

A data dictionary for the model variables is presented in table 5.1. Appendix D summarizes the coded data used in the regression analysis.

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Table 5.1 Definition and Coding of Regression Variables

Variable Name	Description	Type of Variable	Coding
SSI	Startup Success Index. This variable measures the overall success of the startup. It is the dependent variable in the regression analyses.	Continuous	An index number ranging from 0 to 100: No units
REG	Indicator of the presence of external factors on the project. It is an attempt to capture the effect of the macroenvironment on the outcome of the startup. External effects are present if the interviewee reports them as a causal factor; the objective of the project was to meet a governmental regulatory requirement or the project owner was a governmental body.	Categorical	1 = Yes 0 = No
SITE	Indicator of the site constraints for the project. Retrofit projects typically involve more complex construction management. They usually include new equipment but also maintenance of existing facilities as well. Grass root projects are constructed on new or unobstructed sites and would have fewer tie-in or sequencing constraints.	Categorical	1 = Retrofit 0 = Grass roots

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Table 5.1 – Continued

Variable Name	Description	Type of Variable	Coding
SUPER	Index scores from the Startup Planning Evaluation Rating tool (SuPER). This is a measure of the level of model implementation.	Continuous	An index number ranging from 0 to 100: No units
TECH	The level of process development. Projects with mature technologies would be expected to have less startup risk than those with new or unproven technologies.	Categorical	1 = Mature 0 = New
TIC Log(TIC)	The total installed cost of the project (TIC). Projects with a low TIC may have fewer resources for planning; or large projects with very high TIC may be so complex that SU may be difficult to sequence effectively. Two cost variables were investigated: 1) Total Installed Cost of the Project: and 2) Log(TIC)	Continuous	Units are in MM (Millions) of dollars.
YEARS	Number of years of experience by the Project Manager (PM).	Continuous	Years

5.2 MODEL SPECIFICATIONS

Conceptually, all of the proposed variables could be significant, but there was no compelling belief as to which one or ones comprised the best-fit

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model. Therefore, an incremental approach to model building was used. Table 5.2 presents a summary of the makeup of the various regression models tested.

SUPER (SuPER tool score) was the variable common to all runs. It represents the basic premise of the conceptual model: Startup planning is critical to startup success. The independent variable TECH (process technology maturity) was added next and retained, as it was shown to be a common differentiating variable for startup success. The other independent variables (SITE, TIC, Log (TIC), YEARS, and REG) were added one at a time to the basic SUPER + TECH model. The statistical hypotheses and tests used to assess the variables in the model are presented below.

Table 5.2 Summary of Regression Variables Modeled

	Regression Variables Included in Run						
Run No.	SUPER	TECH	SITE	TIC $	Log (TIC, $)	YEARS	REG
01	●						
02	●	●					
03	●	●	●				
04	●	●		●			
05	●	●			●		
06	●	●				●	
07	●	●				●	●
08	●	●					●

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5.3 HYPOTHESES AND TEST STATISTICS

- Hypothesis: There is a linear and significant relationship between the level of startup success and 1) the level of startup planning; 2) the level of process technology development; 3) the cost of the project (either in millions of dollars, or the Log $_{10}$(TIC, M $); 4) the number of years of experience of the project manager; 5) the project's site type; and 6) the presence of significant regulatory or social externalities.
- Probability Distribution. The probability distribution of the continuous variables was assumed to be the normal distribution.
- Test Statistics: The following hypothesis tests were performed:
  - **F-test**: This test evaluates the overall significance of the regression model. It was used to estimate the probability that the partial slope coefficients are simultaneously zero. The hypotheses tested varied depending on the number of variables included in the model but when all variables are included the model tested was:

$$H_o : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

vs.

$$H_A : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$$

Accept H_o : $F_{computed} > F_{critical}$

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- **t-test**: This test evaluates the significance of the individual regression coefficients by comparing the computed t-statistic with the t-critical at the specified confidence interval. The results were used to accept or reject the null hypotheses for each of the partial regression coefficients, i.e.

$$H_0 : \beta_i = 0$$

vs.

$$H_A : \beta_i \neq 0$$

Accept $H_0 : t_{\text{statistic}} > t_{\text{critical}}$

- Confidence Interval: Selecting the confidence interval and the accompanying test statistics was difficult given the data's qualitative nature and the small sample size. As such, no set confidence interval was selected. Instead, F-test, t-statistic and probability value (P-values) for each of the variables was reported and evaluated in the context of the conceptual model. Using results from similar studies Gibson and Hamilton (1996) and Tan (1997) as a guide, the following confidence testing rules were adopted:
    - F-test. A 0.05 significance level was used.
    - t-critical / P-values. A 0.05 significance level was used.

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5.4 REGRESSION RESULTS AND INTERPRETATION

The regression modeling was done in a step-wise fashion. Variables were added to the model, R^2 (Coefficient of Determination), the regression coefficients were tested using the F test and t-test to determine if the added variable contributed to the explanation of Startup Success. If yes, the variable was retained; if not, the variable was dropped from the model and another added in its place. Table 5.3 presents a summary of the regression run statistics. Details are presented in Appendix D. An interpretation of the statistics is presented below.

The decision to retain or reject a model variable was based on the methods of Gujarati (1995) and Tufte (1974). These methods are summarized by responses to the following questions:

- *What do the plots look like?* This is a graphical comparison between of the Regression Standardized Predicted Value and the Startup Success Index.
- *How well does the model explain the results?* This is a check of the overall significance of the specified model, which is an evaluation of the F-test and R^2 results.
- *What is the confidence level for the various coefficients?* This is an evaluation of the Student t-test and corresponding p-value results to assess the confidence interval for rejecting the null hypothesis (H_o).

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- *Do the results make sense?* This is a qualitative evaluation of the β's (Partial Regression Coefficients) to determine if the coefficients are consistent in sign to the specified conceptual model.

5.4.1 Graphical Comparison

Figure 5.1 presents data plots for each of the runs. All plots show a general linear trend between the regression predicted Startup Success Index and the measured Startup Success Index. A discussion of the graphical results of the regression runs follows.

In Run 02, there is an improvement over Run 01 when the variable TECH is added. In Runs 03, 04, and 05 the linear relationship remains but without noticeable improvement over that seen in RUN 02. In Run 06, a noticeable improvement is evident with the addition of the YEARS variable to the model. Visually, the " best fit" runs occurred in Runs 07 and 08 where the REG variable is added to the SUPER + TECH + YEARS mode

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Table 5.3 Summary of Regression Modeling Results [1]

Run No.	**Variable Stats & Coeff.**	**Regression Variable**							**Overall Model Characteristics**	
		SUPER	TECH	SITE	TIC $	Log (TIC,$)	YEARS	REG	F (Sign. of F)	R^2
01	**β[2]**	0.55							4.99	0.17
	t-stat	2.236							(0.03)	
	P-value	0.03								
02	**β**	0.52	15.34						5.44	0.32
	t-stat	2.267	2.244						(0.01)	
	P-value	0.03	0.03							
03	**β**	0.52	14.84	1.99					3.50	0.32
	t-stat	2.223	2.032	0.27					(0.03)	
	P-value	0.037	0.054	0.79						

Table 5.3 - Continued

Run No.	Variable Stats & Coeff.	Regression Variable							Overall Model Characteristics	
		SUPER	TECH	SITE	TIC $	Log (TIC,$)	YEARS	REG	F (Sign. of F)	R^2
04	β	0.50	15.32		0.002				3.49	0.32
	t-stat	2.087	2.185		0.23				(0.03)	
	P-value	0.049	0.040		0.82					
05	β	0.58	14.87			-2.88			3.568	0.33
	t-stat	2.136	2.102			-0.45			(0.03)	
	P-value	0.04	0.047			0.65				
06	β	0.50	16.34				-0.89		5.910	0.45
	t-stat	2.361	2.574				-2.231		(0.004)	
	P-value	0.027	0.017				0.036			

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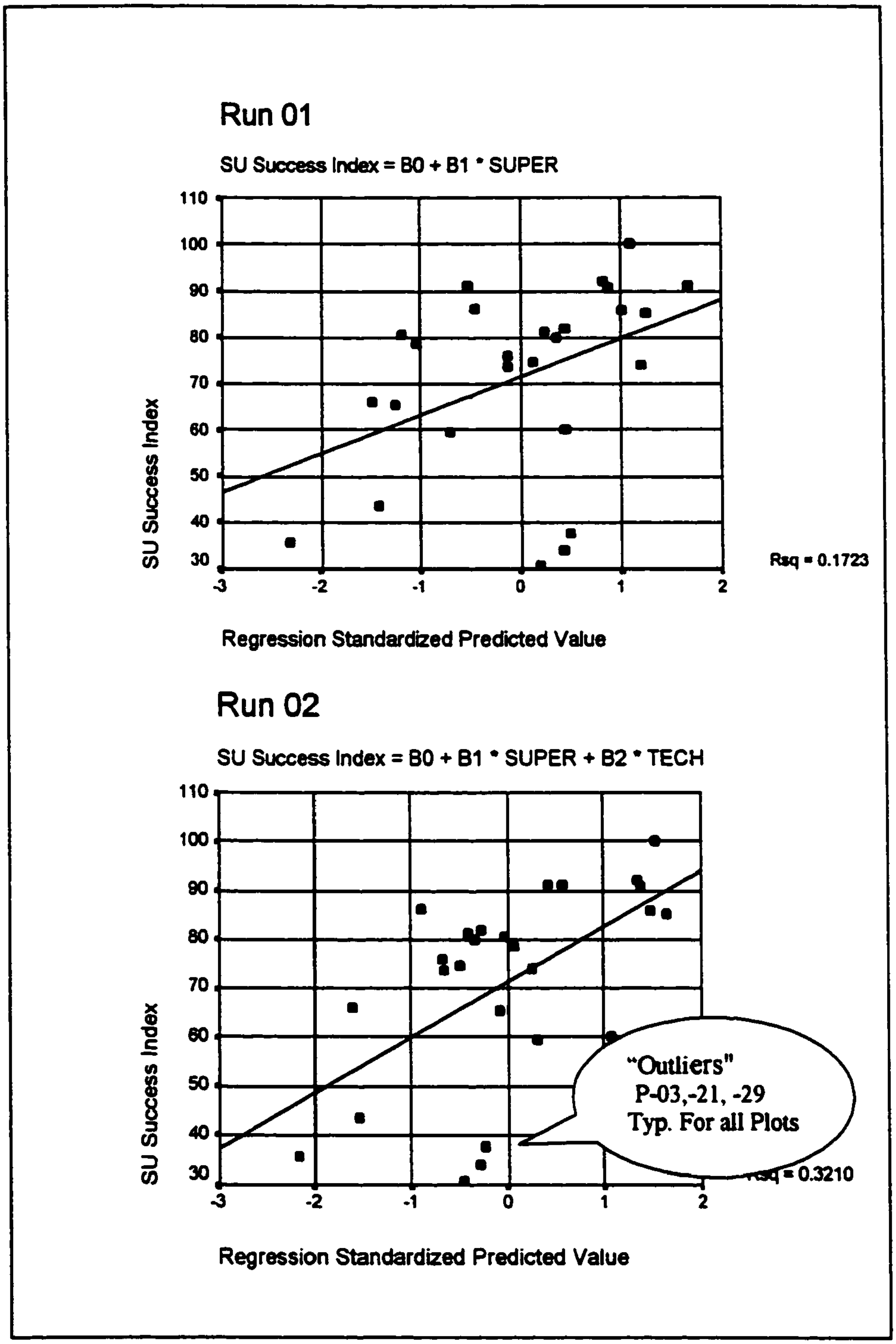
Table 5.3 - Continued

Run No.	Variable Stats & Coeff.	Regression Variable							Overall Model Characteristics	
		SUPER	TECH	SITE	TIC $	Log (TIC,$)	YEARS	REG	F (Sign. of F)	R^2
07	β	0.51	10.6				-0.58	-13.28	12.62 (0.00)	0.74
	t-stat	3.821	2.705				-2.321	-2.312		
	P-value	0.001	0.014				0.032	0.033		
08	β	0.31	15.97					-29.24	19.9 (0.00)	0.73
	t-stat	2.059	3.614					-5.786		
	P-value	0.05	0.002					0.00		

Notes:

1. Complete regression results are presented in the Appendix D.
2. β = The computed partial slope coefficient for the variable included in the regression. The intercept term, β_0, is not analyzed but the value can be found in the Appendix D.



Run 01

SU Success Index = B0 + B1 * SUPER

Run 02

SU Success Index = B0 + B1 * SUPER + B2 * TECH

"Outliers"
P-03,-21, -29
Typ. For all Plots

Figure 5.1 Graphic Summary of Model Results

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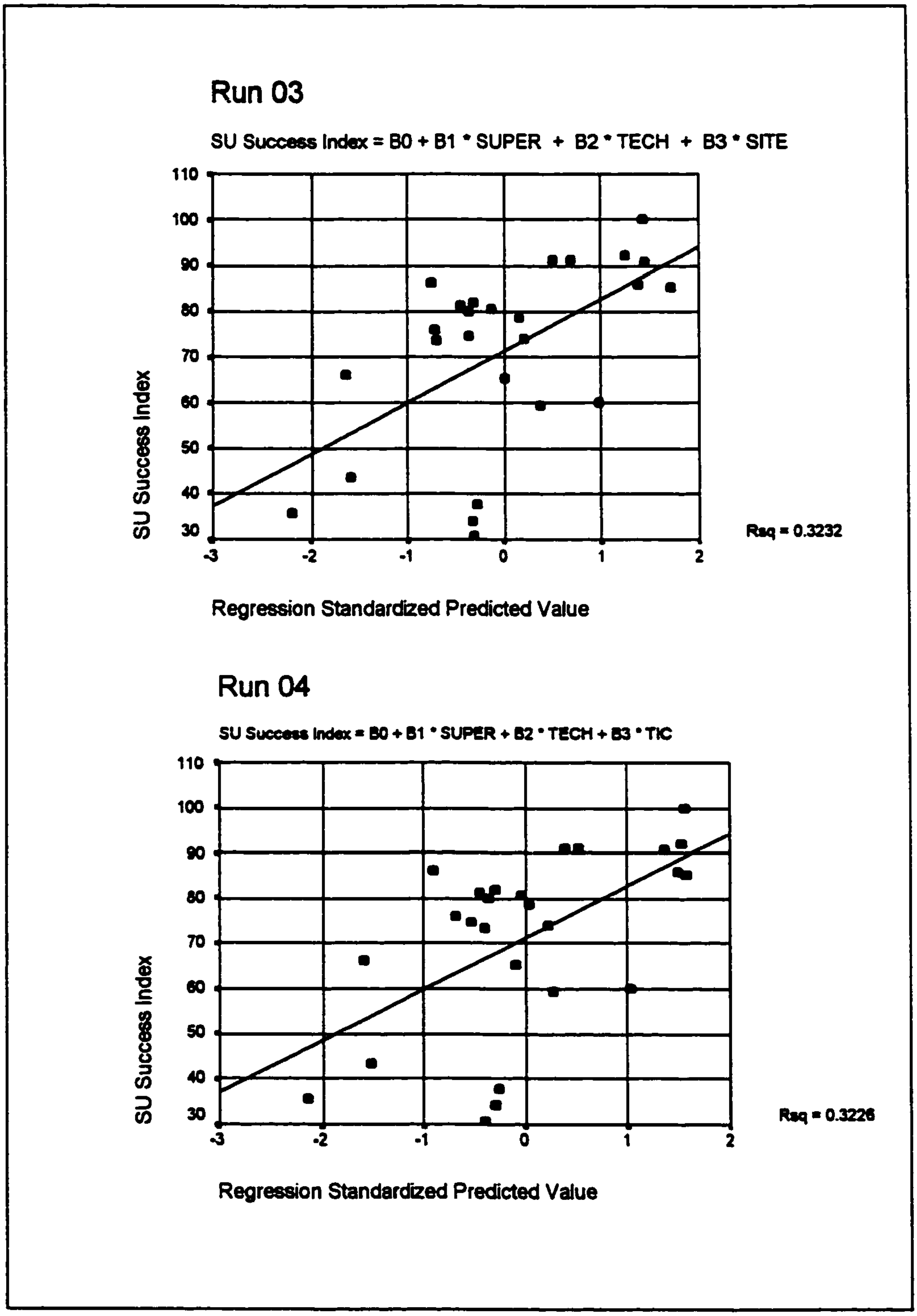

Figure 5.1- Continued

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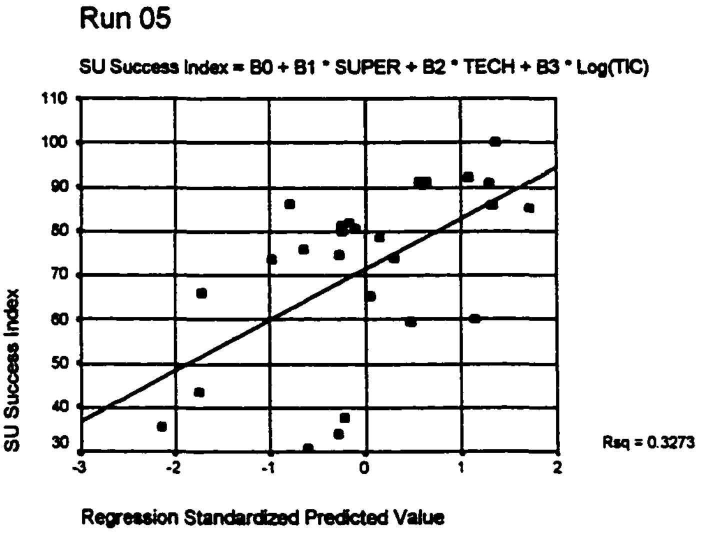
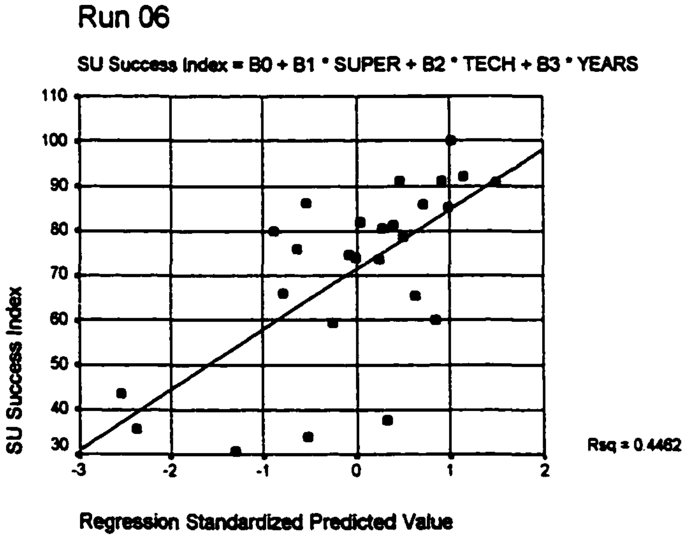


Run 05

SU Success Index = B0 + B1 * SUPER + B2 * TECH + B3 * Log(TIC)



Run 06

SU Success Index = B0 + B1 * SUPER + B2 * TECH + B3 * YEARS

Figure 5.1 - Continued

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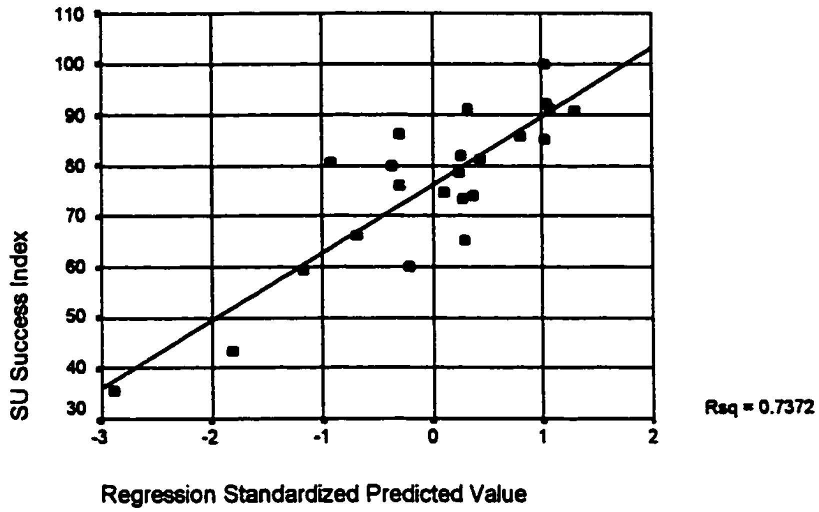
Run 07

SU Success Index = B0 + B1*SUPER + B2*TECH + B3*YEARS + B4*REG



Run 08

SU Success Index = B0 + B1 * SUPER + B2 * TECH + B3 * REG

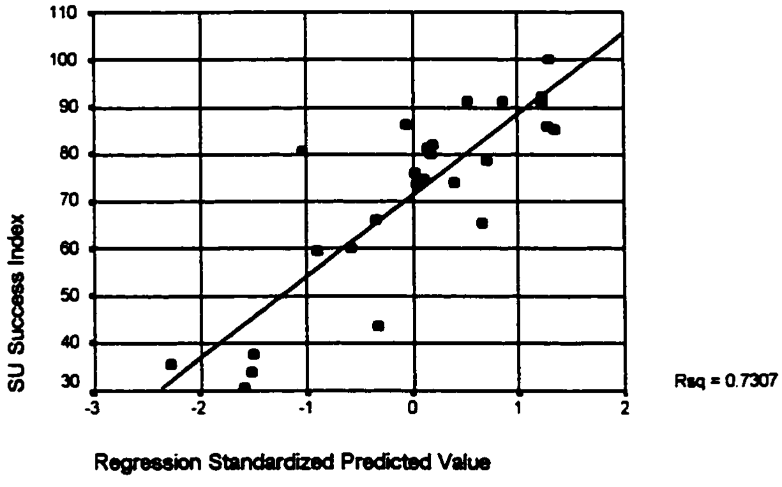


Figure 5.1 - Continued

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5.4.2 Overall Significance of Variables

Table 5.4 summarizes the overall significance variables for each model run. Table 5.5 summarizes the computed coefficients for the variables in each model run. Complete regression results for each run are presented in Appendix D.

Table 5.4 Summary of Overall Significance Variables

Run No	Model Variables	R^2	ΔR^2	F_{test}	$F_{0.05}$
01	SUPER	0.17	–	4.99	0.03
02	SUPER + TECH	0.32	0.15	5.44	0.03
02A[1]	SUPER + TECH	0.54	0.18	11.50	0.00
03	SUPER + TECH + SITE	0.32	0.00	3.50	0.08
04	SUPER + TECH + TIC	0.32	0.00	3.49	0.08
05	SUPER + TECH + Log(TIC)	0.33	0.01	3.57	0.07
06	SUPER + TECH + YEARS	0.45	0.12	5.91	0.02
07	SUPER + TECH + YEARS + REG	0.74	0.29	12.62	0.00
08	SUPER + TECH + REG	0.73	-0.01	19.90	0.00

[1] This run is that same as Run 02 except outlier projects P-03, -21, -29 are excluded.

R^2 values for all runs range from a low of 0.17 (Run 01) to a maximum of 0.74 (Run 07). The initial low value in Run 02, the run measuring the effect of the Startup Model implementation and level of technology development, is primarily due to the 3-outlier projects P-03, P-21 and P-29 (see figure 5.1/ Run 02 for their location).

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08), and the continuous variable YEARS (Run 06) are added, the R^2 and ΔR^2 values increase. In contrast, when the variables SITE (Run 03), TIC (Run 04), or Log (TIC) (Run 05) are added to the basic model no increases in ΔR^2 are seen.

The F-test results are consistent and demonstrate the relevancy of the variables in the overall model. We can reject the null hypothesis for all runs and conclude, that at a confidence level of 95%, there are no runs where all of the coefficients are zero. By rejecting the null hypothesis that all of the regression coefficients are simultaneously zero the question becomes: "Which of the coefficients are the most significant?" The answer can be found by evaluating the t-statistics for each of the coefficients (Gujarati 1995).

5.4.3 t-Statistics

Table 5.6 compares the t-statistics and P-values for the runs and discusses the reasoning for including or eliminating the variable from the regression model. In summary, the partial regression coefficients for SUPER, TECH, and YEARS were retained because they were shown to be statistically different from zero at a confidence interval greater than 95%. The regression coefficients for the remaining three variables, SITE, TIC and Log (TIC) were not significantly different from zero and were dropped from the regression model. A detailed discussion of the analysis is presented in table 5.6

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Table 5.6 Comparison and Assessment of t-test Results [1]

Variable	$\lvert t_{computed} \rvert$ [2]	P-value [3]	Statistically Significant? [4]	Discussion
SUPER	2.236 - 3.821	0.05 - 0.00	Yes	In all runs SUPER is statistically significant. The p-values are all below the test of 0.05.
TECH	2.032 - 3.614	0.05 - 0.01	Yes	TECH is statistically significant and is retained. In all cases its value was overwhelming more significant than the variables TIC, log(TIC) or SITE. The variation suggests the category is ambiguous and may need further definition. For this evaluation, new technology applies to the primary process technology.
YEARS	(-2.231) - (-2.321)	0.04 - 0.03	Yes	Statistically the variable meets the t-test criteria and should be retained. It is consistent with our conceptual model that years of project experience are important to successful startups.

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Table 5.5 - Continued

Variable	$\lvert t_{computed} \rvert$ [2]	p-value [3]	Statistically Significant? [4]	Discussion
Log(TIC)	-0.45	0.65	No	Significantly exceeded the 0.05 p-test criteria and were dropped.
TIC	0.23	0.82	No	Significantly exceeded the 0.05 p-test criteria and were dropped.
SITE	0.27	0.79	No	Significantly exceeded the 0.05 p-test criteria and were dropped.
REG	(-2.311)- (-5.786)	0.03-0.00	Yes	Statistically the variable meets the t-test criteria and should be retained. It is consistent with our conceptual model that external regulatory effects are important to successful startups.

Notes:

1. See Appendix D for full results.
2. Absolute value of computed t-data. Ranges indicate min. and max. values.
3. The one-tail probability values corresponding to the computed t-statistics.

5.4.4 Partial Regression Coefficients

At this point, three partial regression coefficients remain that were judged as statistically different than zero. The task then was to assess if these coefficients support the conceptual model for startup success. Specifically, do the results make sense when evaluated in terms of the coefficient sign, its scale, and its consistency within the regression runs?

An evaluation of the partial regression coefficients (the β's) for the retained variables is presented below. In summary—the variables SUPER and TECH were retained; the variable YEARS was conditionally rejected.

Variable: SUPER

Range of β: 0.31 - 0.58

Variable Type: Continuous

Interpretation :

- For every 10-point SUPER Score increase, the SU Success Index increases between 3.1 and 5.8 points.
- The sign is consistent with the conceptual model, which assumes that a higher SUPER score indicates more startup planning effort, which is related to a more successful startup.
- The coefficient and sign are consistent for all model runs.

Conclusion: Retain

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Variable: TECH

Range of β: 10.6 - 16.3

Variable Type: Categorical

Interpretation :

- The coefficient indicates that a project with a mature technology adds between 10.6 to 16.3 points to Startup Success Index.

- The sign and scale are consistent with our conceptual model: for a given level of startup planning effort, a mature process startup will have a higher Startup Success Index than one with a new or unproven process startup.

Conclusion: Retain

Variable: REG

Range of β: (-13.2) - (-29.2)

Variable Type: Categorical

Interpretation:

- The coefficient indicates that regulatory externalities such as environmental regulations, government-sponsored projects, or poor labor relationship have a significant effect on startup success.

- The coefficient indicates that a project with a significant REG component will reduce the startup success index between 13.2 and 29.2 points.

- The sign and scale are consistent with our conceptual model. The range suggests the category is ambiguous and needs further definition

Conclusion: Retain

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One apparent difference between this work and the previous researchers work, is the inclusion of the externality variable, REG. Previous studies (Merrow 1988; Myers et al. 1986; Avots 1983) have demonstrated the importance of the externality variable in predicting project and startup success.

The regression analysis demonstrated a statistically significant relationship exists between the Startup Success Index and the level of implementation of the Planning for Startup (i.e. the SuPER score). The analysis also demonstrated that planning is not the only variable affecting startup success. The level of technological development (i.e. TECH) and the social environment of the project (i.e. REG) were both significantly related to startup success. Projects with mature technologies were shown to have a higher level of startup success over those with new technology for a given level of startup planning. Conversely, projects with significant external factors were shown to have a lower level of startup success over those with no external factors with a given level of startup planning. The variables TIC, Log (TIC), and SITE were not statistically related to startup success and were rejected from the model.

The variable YEARS was the most confusing. It was shown to be significant in the t-test results and initially retained. However upon further analysis of the sign of the partial regression coefficient in was conditionally rejected from the model. It was concluded that the negative coefficient was an artifact of the survey methodology and may reflect the study's bias in selecting projects with "very successful" or "very unsuccessful" startups or lack of

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specificity in the questionnaire by not determining the years of startup experience. Ultimately, the variable YEARS was dropped from the model.

The sample size is small in number but deep in content which gives credence to the conclusions made in the analysis. However additional work is needed to more precisely define the TECH (technology development) and REG (external or regulatory) effects on startup success. Although, the conclusions of this research support the work reported by Merrow (1988) and Myers et al. (1986), it did not identify any corrective measures that could be used to mitigate these effects on startup success. Additional research is needed into projects that, in spite of using new technology or the presence of external regulatory effects, overcame these factors and achieved startup success.

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Chapter 6 Analysis of Startup Success with Other Project Variables

6.1 INTRODUCTION

In the previous chapter the relationship between startup success and various project characteristics including the level of startup planning was analyzed. In this chapter, the startup planning component of startup success is further analyzed to assess the relationship between the Startup Success Index and the individual activities in the Planning for Startup model. The analysis was performed using the following techniques:

- Bivariate Analysis of Planning Activities was used to analyze the relationship between planning effort and planning timing for 28 activities in the Planning for Startup model. Specifically, the bivariate analysis approach tested two data sets:
  1) the relationship between the activities planning effort scores and the startup success index and;
  2) the relationship between the activities phase of execution and the startup success index.
- Analysis of Categorical Means was used to analyze the differences between the startup planning timing scores and startup effort scores for the categories of "very successful" startups and "very unsuccessful" startups.

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- Analysis of Startup Management Practices was a mixture of graphical and statistical techniques to analyze the relationship between startup success and selected startup planning management decisions including: startup duration; the timing of the assignment of the startup manager to the project team; the frequency of formal startup training; and the timing of startup systems identification.

6.2 BIVARIATE ANALYSIS OF STARTUP PLANNING ACTIVITIES

Conceptually, the bivariate correlation analysis examines the relationship between paired sets of independent and dependent variables. It assumes that a simple linear relationship exists between the independent and dependent variables and that the paired variables are distributed normally (SPSS 1990).

This technique was used to statistically test how well changes in the level of the startup planning effort, or changes in the phase of startup planning, tracked with changes in the Startup Success Index. The strength of the activities' relationship to startup success was measured by the Pearson correlation coefficient, r. The statistical significance of r was assessed by relating its value to a Student t distribution, then tested against the acceptance criteria to identify the most effort sensitive, or phase sensitive activities in the planning model.

6.2.1 Methodology, Hypotheses and Test Statistics

Two types of Activity Planning Scores were evaluated including 1) the level of planning effort scores; and 2) the phase of execution scores for the

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planning activity. (Note: A discussion of the scoring methodologies is presented in Chapter 3). The data set was constructed by pairing the independent variables, activity planning effort or activity planning timing scores, with the dependent variable, Startup Success Index scores. Activity planning and Activity efforts scores collected from the interview data are presented in Appendix C. These data were paired and tested using the following conceptual models and tests:

- Conceptual Models

$$[\text{Startup Success Index}]_i = \beta_0 + \beta_1 * [\text{ Activity Effort Score }]_{i,j}$$

or

$$[\text{ Startup Success Index }]_i = \beta_0 - \beta_1 * [\text{Activity Phase Score}]_{i,j}$$

Where:

i= Project ID

j= Planning Activity ID

An example of this conceptual model applied to the effort data for the model activity 6-D "Conduct Operator/Maintenance Training" is presented in figure 6.1.

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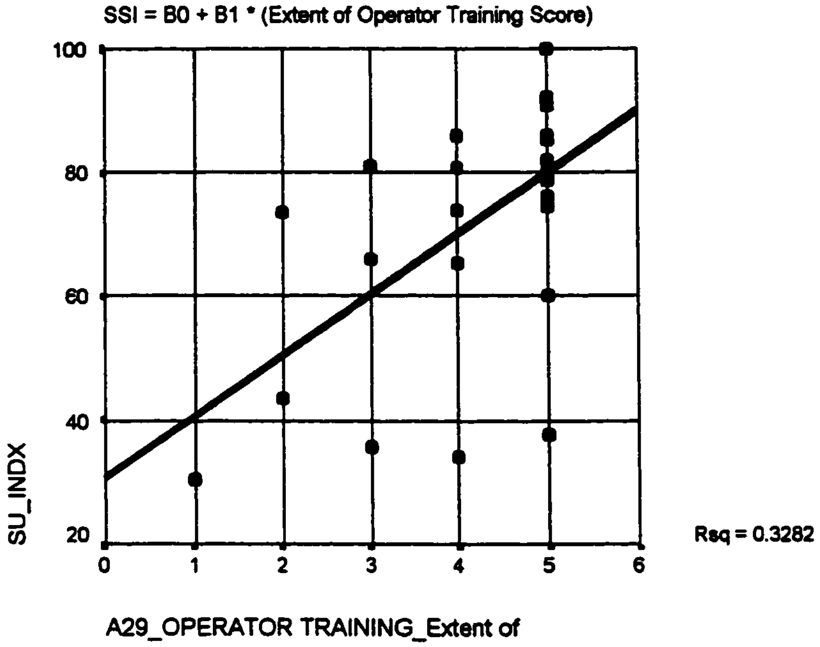

Figure 6.1 Example Plot of Bivariate Analysis

From the linear regression analysis the sample or Pearson correlation coefficient, r, was computed. This correlation coefficient is typically used as a general summary index to indicate the strength of the relationship. To test its significance and an additional calculation to relate r to a known distribution is necessary. The conversion of r to the t statistics is computed as follows:

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$$t_{\text{test}} = (r)\sqrt{\frac{n-2}{1-r^2}}$$

so, for the example, compute t_{test}

$$t_{\text{test}} = (0.33)\sqrt{\frac{25-2}{1-0.33^2}}$$

$t_{test} = 3.352$

With this, the traditional hypothesis testing techniques can be used to test the significance of the computed Pearson correlation Coefficient *r*. The null hypothesis, H_0, assumes there is no linear relationship (i.e. r = 0) between the variables and therefore could be accepted or rejected based on the t-test statistics. A one-tail test was adopted because the conceptual models assume there was either a positive relationship between planning effort and startup success, or a negative relationship between planning timing (e.g. project phase) and startup success. The general hypotheses and test statistic is presented below.

- Hypothesis

  H_0: r = 0

  H_A: |r| > 0

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- Test Statistics

  One tail t-test.

  Reject H_0 if $P \leq 0.05$

The remaining details of the significance testing for this example are presented in Appendix E.

6.2.2 Effort Results

Bivariate regression results for the planning effort analysis is summarized in table 6.1. The results show that effort level scores for four of the 28 activities were significantly related to startup success. See Appendix E for the complete results of the bivariate analysis.

Table 6.1 Significant Relationships Between Effort and Startup Success

Model ID	Description of Planning Activity	Correlation Coefficient, *r*	Significance Level [1]
2-A	Seek a Realistic Forecast of Startup Duration	0.432	0.05
3-A	Establish Startup Objectives	0.335	0.05
6-D	Conduct Operator Training	0.573	0.01
8-C	Performance Measures and Final Report	0.440	0.05

Note:

[1] SPSS reports significance categorically as either ≤ 0.05 or ≤ 0.01.

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6.2.2 Phase Results

The bivariate analysis of the activity timing data identified 12 activities that were significantly related. A listing of these activities, along with its phase of execution is summarized in table 6.2.

6.3 ANALYSIS OF CATEGORICAL MEANS

This section presents the analysis of the differences in planning effort and planning timing between "very successful" and "very unsuccessful" startups. As with the bivariate analysis, the goal was to identify model activities where higher levels of planning and/or earlier planning efforts were associated with successful startups

This analytical method took advantage of the sample set's built-in bias toward "very unsuccessful" or "very successful" startups; its disadvantage was the inability to rigorously control for other factors, such as, the interaction between other planning activities or the effect of the project environment on startup planning.

Despite these limitations, this kind of analysis provides qualitative information on what differentiates "very unsuccessful" startups from "very successful" startups. These results also provide insight and lend credence to the conclusions drawn from the more statistically rigorous bivariate analysis

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Table 6.2 Significant Relationship Between Timing and Startup Success

Phase of Execution	Model Id	Activity Description	Correlation Coefficient, *r*	Signif. Level[1]
Front-End Engineering	3-C	Make Startup Team Assignments	-0.51	0.01
	3-D	Identify Startup Systems	-0.37	0.05
	3-E	Acquire Operations & Maintenance Input	-0.39	0.05
	3-F	Assess Startup Risks	-0.54	0.01
	3-G	Analyze Startup Incentives	-0.69	0.01
Detailed Design	4-B	Assess & Communicate Startup Effects From Changes	-0.35	0.05
	4-C	Plan For Supplier Field Support Of Startup	-0.42	0.05
	4-E	Plan For Startup QA/QC	-0.38	0.05
	4-L	Develop System Turnover Plan	-0.45	0.05
	4-M	Develop & Communicate Startup Procedures And Process Safety Management	-0.39	0.05
Construction	6-B	Conduct Construction-Startup Team Building	-0.35	0.05
	6-G	Transition To System Based Execution	-0.50	0.01

Note:

[1] SPSS reports significance categorically as either ≤ 0.05 or ≤ 0.01.

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6.3.1 Methodology

The analytical methodology follows the traditional statistical approach of hypothesis testing by comparison of means (Freund 1992). A summary of the process is presented below:

1. Develop criteria and categorize startup success. Use criteria to group the projects into categories of 1)"very successful" startups; 2) "very unsuccessful" startups; or 3) "as-expected" startups. (See Chapter 3 for a discussion of the criteria and methodology for categorizing startups.)
2. Select the "very successful" and "very unsuccessful" groups and assemble a sub-group data set consisting of the effort and phase data.
3. Develop a test hypothesis and test statistics.
4. For the two groupings, compute the mean effort score and mean phase scores for each of the model planning activities.
5. Compute the difference between the means and statistically test the differences using the two-sample t-test.

6.3.2 Hypotheses and Test Statistics

Testing the Differences in Planning Effort:

- Conceptual Model. Conceptually this test was designed to answer the question: "Is there a difference between mean effort scores of "very successful" and "very unsuccessful" startups?"

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- Hypotheses. Statistically the question is answered by accepting or rejecting the null hypothesis, H_0, which states there is no difference between the two effort levels. The alternative hypothesis, H_A, is that the effort level in successful startups is higher that in unsuccessful project. Mathematically they are expressed as:

$$H_0 : [\, X\,i_{\textit{successful}} - X\,i_{\textit{unsuccessful}} \,] = 0$$

or;

$$H_A : [\, X\,i_{\textit{successful}} - X\,i_{\textit{unsuccessful}} \,] > 0$$

Where:

- X i = Mean Effort Score for Planning Activity "i".

- Test Statistics:
    - One tail t-test
    - Significance Level to Reject H_0, $\leq$ 0.05

Testing the Differences in Planning Timing

- Conceptual Model this test is designed to answer the conceptual question: "Is there a difference between "very successful" and "very unsuccessful" startups in the average phase of when a planning activity was initiated?"

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- Hypotheses: The null hypothesis, H_0, states there is no difference in timing between a "very successful" and a "very unsuccessful" startup. The alternative hypothesis, H_A, states that "very successful" startups initiate a planning activity earlier than "very unsuccessful" startups. These hypotheses are expressed mathematically as:

$$H_0 : [\, X\,i_{\,successful} - X\,i_{\,unsuccessful} \,] = 0$$

or

$$H_A : [\, X\,i_{\,successful} - X\,i_{\,unsuccessful} \,] < 0$$

Where:

$X\,i$ = Mean Phase Score for Planning Activity "i".

- Test Statistics:
  - One tail t-test
  - Significance Level to Reject $H_0 \leq 0.05$

Mean values for the activities in the two groups were computed and paired. Difference computation and hypothesis testing was performed using the statistical package included in Excel 97. Results and interpretations were made using the methods of Freund (1992) and Middleton (1997). The results of the analyses are summarized and discussed below. Complete results are presented in Appendix E.

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6.3.3 Results of Categorical Means Analysis

Effort Differences The results show that "very successful" startups exert significantly more effort than "very unsuccessful" startups in four startup planning activities. Table 6.3 presents the model identification number, activity name and significance level. Significance test results for all activities are presented in Appendix E.

Table 6.3 Activities With Significantly Higher Planning Effort

Model ID	Activity Description	Significance
2-A	Seek a Realistic Forecast of Startup Duration	0.03
2-B	Establish Startup Costs	0.03
6-D	Conduct Operator Training	0.02
8-C	Performance Measures and Final Report	0.04

Timing Differences. When a similar analysis is performed for the planning phase data, "very successful" startups initiated nine of the model planning activities significantly earlier than reported in "very unsuccessful" startups.

The results of the planning differential analysis are summarized in the table 6.4. The table also shows the average phase when the activity was initiated, the initiation phase recommended in the startup model, and a comparison between the two. Significance results for all activities are presented in Appendix E.

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The results show that in "very successful" startups, work on these activities began at the same time or earlier than suggested in the model which suggests that the phase recommended in the model may not be early enough. It is noteworthy that none of the activities were started later than that suggested in the Planning for Startup model.

Table 6.4 Activities Started Significantly Earlier in Very Successful Startups

Model Id	Activity Description	Sign. Level	Avg. Phase of Initiation	Compared w/ Model[1]
3-C	Make Startup Team Assignments	0.03	Front-End Eng.	S
3-D	Identify Startup Systems	0.04	Front-End Eng.	S
3-E	Acquire Operations & Maintenance Input	0.04	Concept. Dev.	E
3-F	Assess Startup Risks	0.02	Concept. Dev.	E
4-A	Address SU Issues In Team Building Sessions.	0.03	Concept Dev.	E
4-B	Assess & Communicate Startup Effects From Changes	0.02	Detailed Design	S
4-C	Plan For Supplier Field Support Of Startup	0.03	Front-End Eng.	E
4-E	Plan For Startup QA/QC	0.02	Concept Dev.	E
4-M	Develop & Communicate Startup Procedures And Process Safety Management	0.02	Front-End Eng.	E

[1] E: Earlier / S : Same / L: Later

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6.3.4 Conclusions and Comparison with Bivariate Analysis

To check the credibility of the categorical analysis, the results of the two analytical methods were compared. The results from the bivariate analysis are statistically the most rigorous but the results from the categorical analysis are useful as they represent an intuitive approach for understanding the "best startups".

Table 6.5 compares the effort sensitive activities identified in the bivariate and categorical means analyses. The comparison shows agreement between the two approaches for three of five activities including activities 2-A , 6-D, and 8-D.

Table 6.5 Comparison Between Effort Results

Model Id	Activity Description	Found Significant in:	
		Bivariate Analysis	Categorical Analysis
2-A	Seek a Realistic Forecast of Startup Duration	●	●
2-B	Estimate Startup Costs		●
3-A	Establish Startup Objectives	●	
6-D	Conduct Operator/Maintenance Training	●	●
8-D	Finalize Documentation	●	●

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Table 6.6 presents a comparison between the phase significant activities identified in the bivariate and categorical analyses. The comparison shows agreement between the two approaches in 8 of the 13 activities sensitive to the phase of activity execution. These activities all occur in one of three project phases: Front-End Engineering, Detailed Design, or Construction. Of interest is the absence of any activities from the initial planning phases of the project, a period when many of the critical objectives and goals of the project are established.

One possible explanation is that during the early phases of a project there is more latitude in the sequence of executing the startup plan, but as the project progresses this freedom to postpone a planned activity without effecting startup success disappears. This explains the differences between the construction phase activities 6-B and 6-G. The bivariate analysis identified these as phase sensitive activities and the categorical analysis did not. The results of the bivariate analysis indicate that these activities must be done in the proper project phase but, as indicated in the results from the categorical analysis, the difference in phase timing between "very successful" from "very unsuccessful" startups was statistically insignificant suggesting that these activities get initiated irrespective of the startup outcome.

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Table 6.6 Comparisons Between Phase Results

Project Phase	Model Id	Activity Description	Found Significant in:	
			Bivariate Analysis	Categorical Analysis
Front End Engineer	3-C	Make Startup Team Assignments	●	●
	3-D	Identify Startup Systems	●	●
	3-E	Acquire Operations & Maintenance Input	●	●
	3-F	Assess Startup Risks	●	●
	3-G	Analyze Startup Incentives	●	
Detail Design	4-A	Address Startup Issues In Team-Building Sessions		●
	4-C	Plan For Supplier Field Support	●	●
	4-E	Plan For Startup QA/QC	●	●
	4-B	Assess & Communicate Startup Effects From Changes	●	●
	4-M	Develop And Communicate Startup Procedures And Process Safety Management	●	●
	4-L	Develop System Turnover Plan	●	
Constr.	6-B	Conduct Construction-Startup Team Building	●	
	6-G	Transition To Startup Systems-Based Execution	●	

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6.4 ANALYSIS OF STARTUP MANAGEMENT PRACTICES

During the course of project delivery a number of management decisions are made which may affect the outcome of the project startup. To assess these effects a series of comparisons and analyses were conducted including:

- Estimating Startup Duration: A comparison between the planned and actual startup duration for each project is presented.
- Startup Variance and the SuPER Score: A statistical analysis of the relationship between SuPER tool scores and the accuracy of the startup duration estimate.
- Assigning the Startup Manager. An analysis of the assignment phase; the commitment level (part-time vs. full-time); and the training of the startup manager.
- Startup Responsibility. A reporting of interview data identifying who was responsible for developing the startup duration estimate and who had primary responsibility for conducting the startup.
- Startup Incentives. A discussion of the use of startup incentives to reward startup success.
- Identifying the Startup Systems. An analysis of the timing of startup system identification.

6.4.1 Estimating Startup Duration

The project team has a keen interest in the accuracy of the startup duration estimate and a better understanding of the causes of variance between estimated

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and actual startup duration. Figure 6.2 shows a plot of the startup duration variances (i.e. actual duration minus planned duration) for the sample set. "Planned duration" is defined as the startup duration period estimated at project authorization (a project milestone event that typically occurs at the end of the Conceptual Development / Feasibility Phase of the project).

The sample set shows a wide range of startup duration variances, ranging from 24 weeks earlier than planned, to 48 weeks later than planned. The majority, 15 of 26 projects, were started up at, or earlier than plan. Five of the projects had startups that were completed in three or fewer weeks beyond the originally planned duration. Six of the projects involved startups that exceeded planned duration by seven or more weeks.

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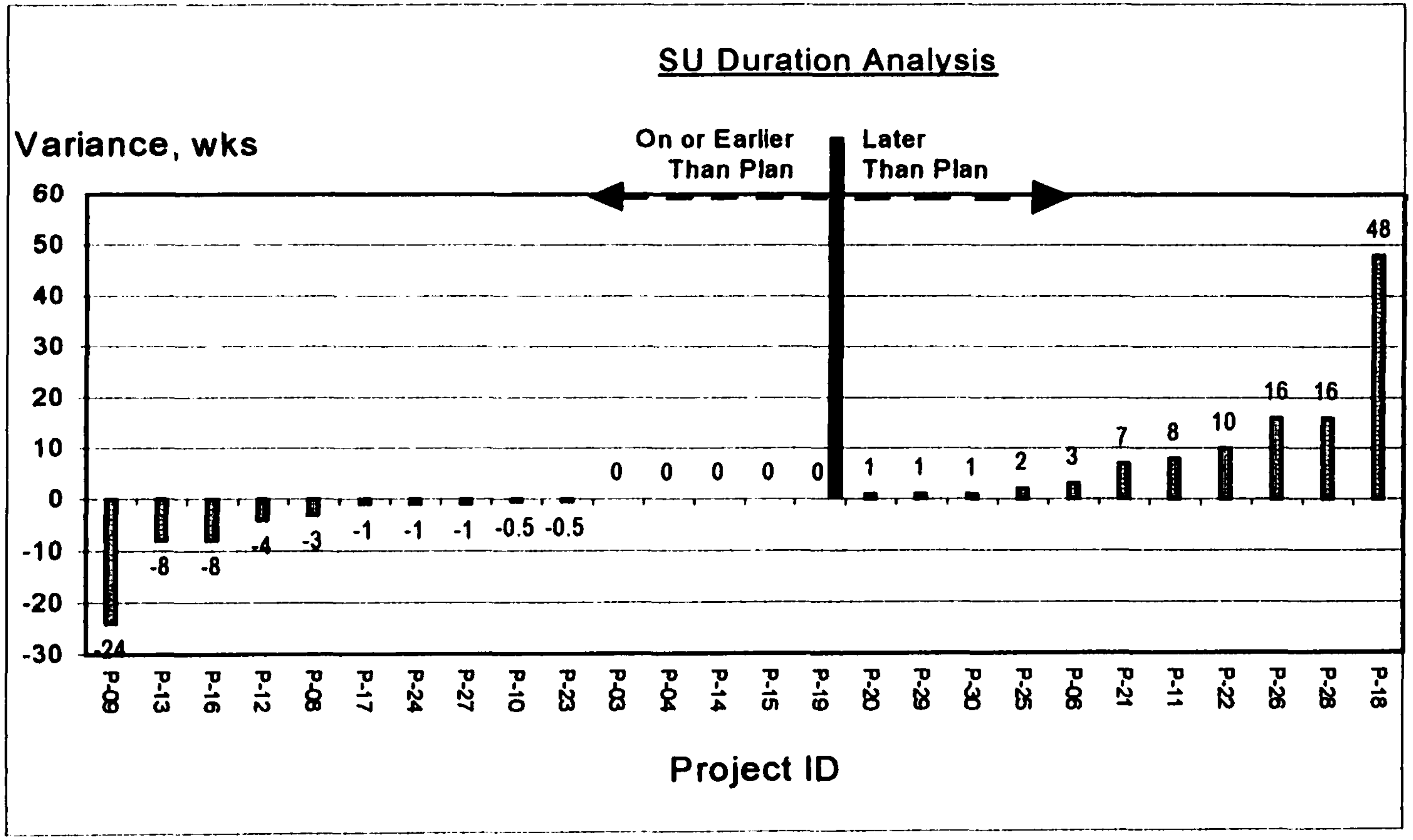

Figure 6.2 Range of Startup Duration Variance

6.4.2 Startup Variance and the SuPER Score

To measure the accuracy of the startup projection, it is useful to standardize the variance data to a more general form as a percent of planned duration. The weekly variance data is converted to this form using the equation below. The results are shown graphically in figure 6.3.

$$\left[\text{Duration Variance \%}\right] = \left[[\text{ Actual } - \text{Planned }] / \text{Planned}\right] * 100$$

A linear regression analysis of the standardized variance data was conducted to evaluate the relationship between the level of planning (the SuPER score) and startup duration variance. A discussion of the conceptual model, hypotheses and analytical results is presented below.

- Conceptual Model:

$$\left[\text{Duration Variance \%}\right] = \beta_0 + \beta_1 * \left[\text{ SuPER Score}\right]$$

- Hypothesis. There is a significant and negative relationship between the level of startup planning (i.e. the SuPER Score) and the startup schedule percent variance. As the level of planning increases the degree of schedule variance decreases. Stated mathematically, the null and alternative hypothesis are described as:

  $H_0 : \beta_1 = 0$

  $H_A : \beta_1 < 0$

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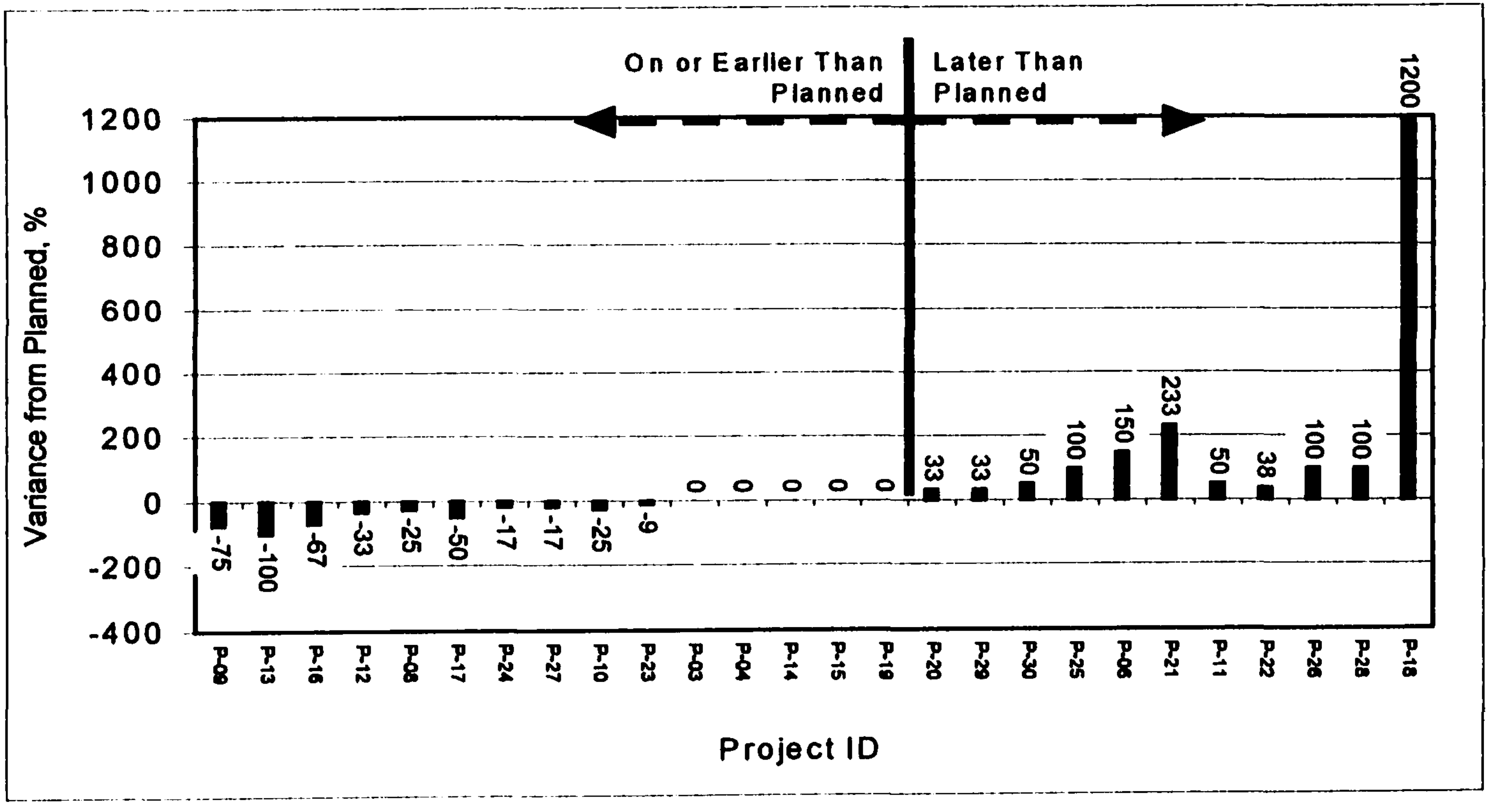

Figure 6.3 Startup Duration Variance as a Percent o f Planned

- Test Statistics

One tail t-test.

Significance Level to Reject $H_o \leq 0.05$

Regression Results and Interpretation

Figure 6.4 shows a scatter plot of the data (less one outlier P-18) and the best fit linear regression line and equation. It shows a marginally linear relationship between the SuPER score and the variance of the startup duration estimate.

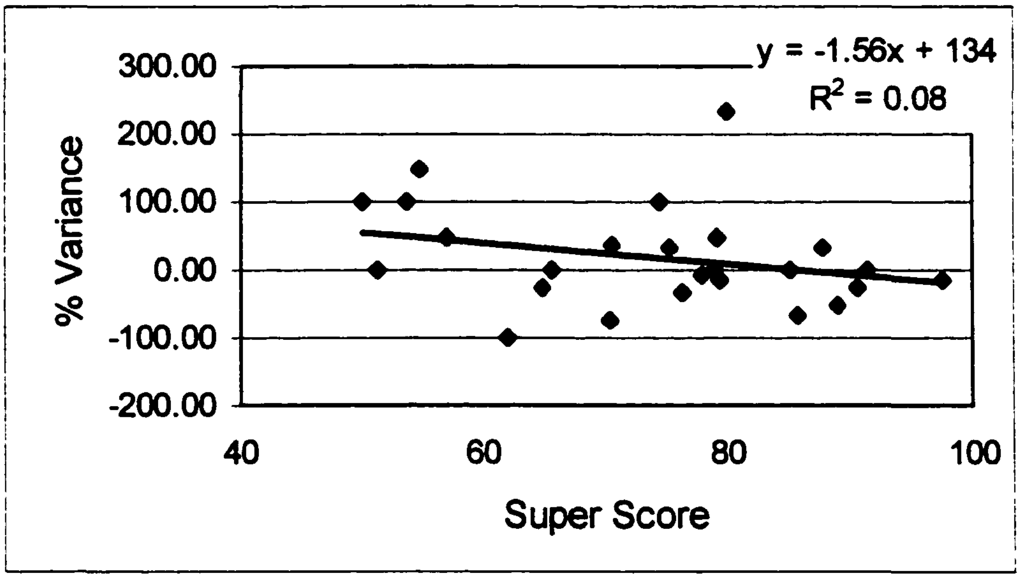

Figure 6.4 Super Score vs. Startup Duration Variance, %

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Although the regression t-test statistics were statistically significant, a R^2 of 0.08 is low, suggesting there are other variables besides startup planning that contribute to the startup duration variance.

6.4.3 Startup Responsibility

The initial estimate of the startup duration is important for the project team and its sponsors. One aspect of the research effort was to identify the party responsible for developing the startup duration estimate. Findings from project interviews indicate that approximately 77% of the time the owner's representative acts alone in making the initial duration estimate, with the project team making the decision about 15% of the time, and a contractor representative making the decision about 8% of the time. These results are expected given that most of these estimates were made during the authorization phase of the project, a period when the project team is primarily comprised of owner staff. The data indicates that it is most often the owner's project manager that develops the startup duration estimate.

The interview data also adds insight into what organizations are most often responsible for the startup phase. In this research, the owner was responsible for all but four of the startups studied, with contractors being responsible for those.

6.4.4 Startup Manager Assignment and Training

The assignment of the startup manager is a critical step in the startup planning effort. It is worth noting that four of the five phase-sensitive Front-End

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Engineering planning activities directly involve the startup manager (i.e. model activities 3-C, 3-D, 3-E, and 3-F) so his/her assignment is an important event in the execution of the project. Four questions related to the assignment and training of the startup manager were addressed in the research including:

1. Is there a relationship between the phase of startup manager assignment and startup success?
2. Is there a relationship between the size of the project and the initial commitment of the startup manager?
3. Is there a relationship between the initial commitment of the startup manager and startup success?
4. Is there a relationship between the manager's startup training and startup success?

A discussion of the research results is presented below.

Assignment Phase and Success. Figure 6.5 shows the distribution of the startup manager assignments and the corresponding range of startup success. Excluding the Requirements Definition phase results, the plot shows the timing of the assignment to be fairly evenly distributed over a near uniform range of Startup Success Index scores.

One-half (13 of 26) of the projects had a startup manager identified on or before the phase recommended in the Planning for Startup model; they also had the highest median Startup Success Index. Projects that assigned the startup manager after the Feasibility Phase experienced increasing variability in startup success.

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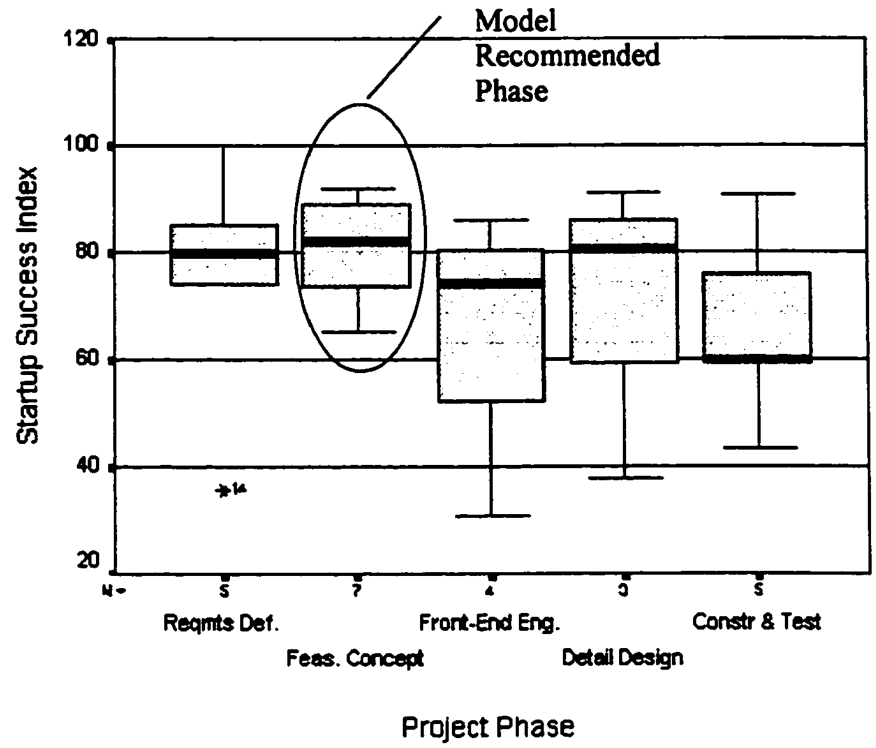

Figure 6.5 Startup Manager Assignment and Success

Project Size and Startup Manager Commitment. As project size increases there may be a perceived need to make the initial commitment of the startup manager a full-time one. Figure 6.6 present a box-plot showing the relationship between the size of the project and the initial time commitment of the startup manager. Using the median project size as a guide, project size does not appear to affect the decision to commit the startup manager for a full time or part time role.

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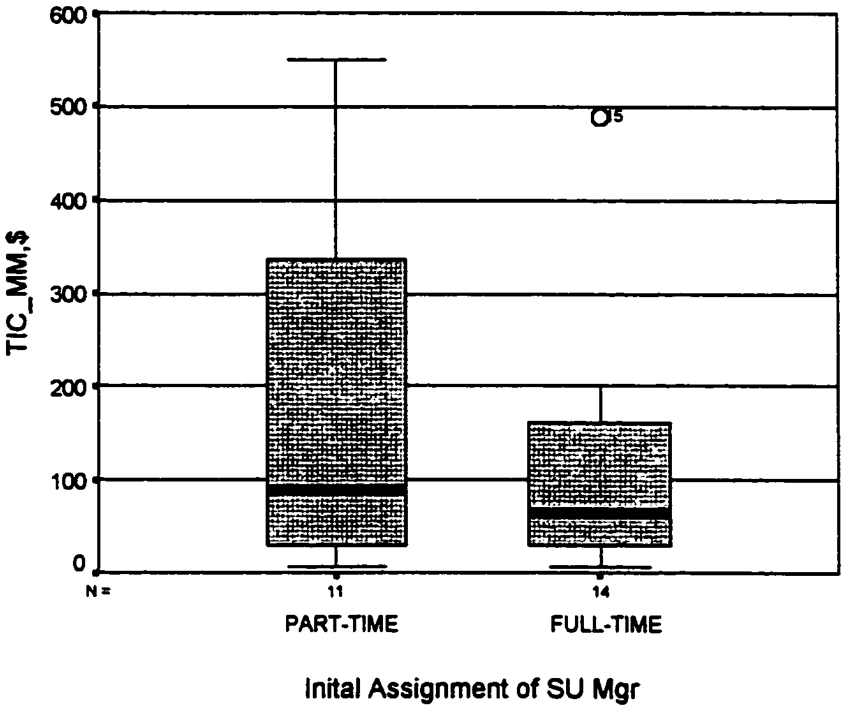

Figure 6.6 Commitment of the Startup Mgr. and Project Size

Initial Commitment and Startup Success. Figure 6.7 shows a box plot of the range of startup success for projects with part-time and full-time startup managers. When compared, projects with an initial full-time commitment by the startup manager have a higher median success index and less variation than those projects where the initial commitment was a part-time one.

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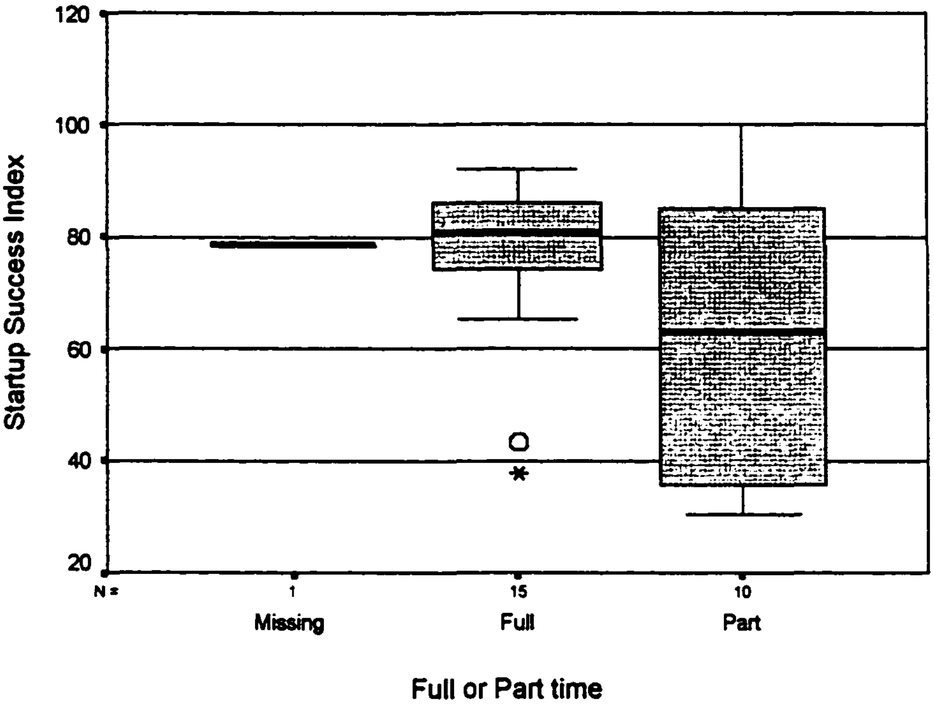

Figure 6.7 Initial Commitment of SU Manager and Success

Startup Training and Success Traditionally, startup manager training occurs as a progression of on-the-job-experiences, but today there are formal courses that focus on startup training. Figure 6.8 shows that only 8 of 26 (approximately 30%) of the startup managers in this survey received some type of formal startup training.

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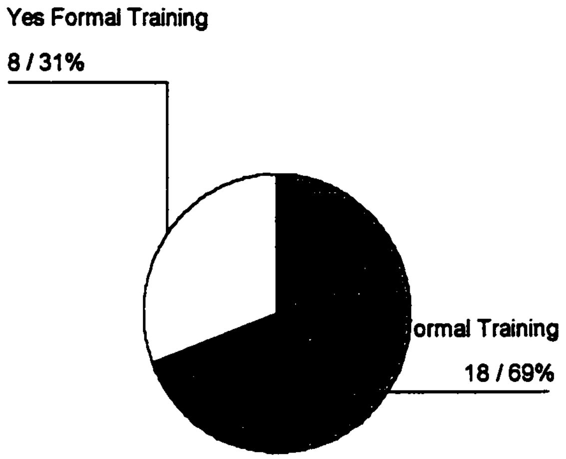

Figure of 6.8 Frequency of Formal SU Training

The effect of this training on startup success is not clear. Figure 6.9 shows a box plot of startup success scores for project lead by startup managers with and without formal startup training. Both groups had similar success levels but differ in the range of the startup success. Projects lead by formally trained startup managers showed less variation in the level of startup success.

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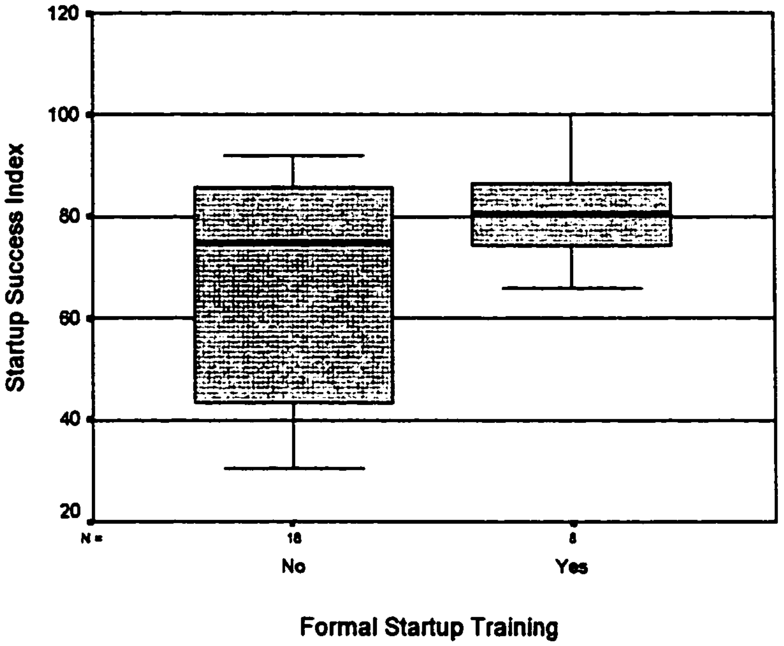

Figure 6.9 Formal Startup Training and Startup Success

6.4.5 Startup Incentives

Model activity 3-G: Analysis of Startup Incentives was identified as a phase sensitive activity and therefore could be viewed as a management tool to improve startup success. Interview results on this issue are interesting in that approximately 42% (11 of 26) of the projects in the sample considered startup incentives yet none used them to exclusively reward startup performance. Interviewee comments indicate that when an incentive program was adopted, it was structured to reward the entire project team for the overall success of the project.

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6.4.6 Identification of Startup Systems

Model activity 3-D: Identify Startup Systems was also identified as a phase sensitive activity. Identification of startup systems is critical to a successful startup because it provides the startup team a framework for sequencing the acceptance of completed portion of the work and initiating startup-training activities. It also has the potential to be a useful management tool because it provides a measurable work product indicating project progress and can serve as an effective communication device for the design, construction and startup teams.

Figure 6.10 summarizes the project phase of system identification and its relationship to startup success. The systems were identified as early as the Feasibility-Concept phase and as late as the Pre-Operational Testing phase. The plot also shows startup success to be higher and less variable if systems are identified in the Front-End phase (the phase recommended in the Planning for Startup model) or the Detail Design phase of the project.

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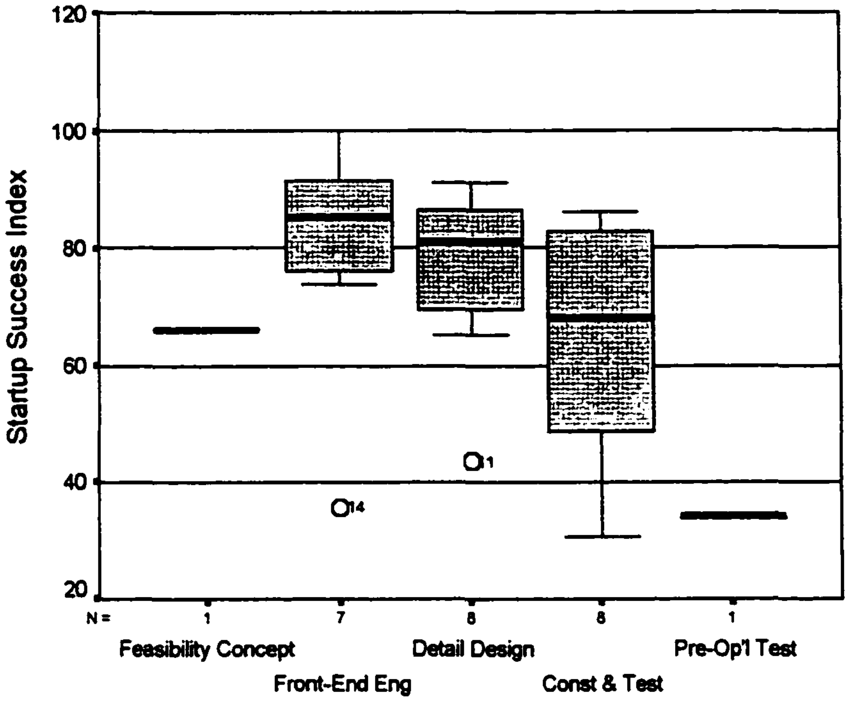

Figure 6.10 Phase of System Identification and SSI

When the system identification data for the "very successful" and "very unsuccessful" startups are sorted, the pattern presented in table 6.8 emerges. "Very successful" startups tend to identify systems earlier than "very unsuccessful" startups. Systems in the "very successful" group were identified no later than the end of the Detailed Design phase in contrast to the "very unsuccessful" group that tended to spread the decision over a wide range of project phases.

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Table 6.7 System Identification in Very Successful and Very Unsuccessful Startups

Success Class	Project Phase			
	Front-End Engineering	Detailed Design	Construction	Test. & Commissioning
Very Successful	XXX	XX		
Very Unsuccessful	X	X	XX	X

6.5 CONCLUSION

This concludes the analysis of the effect of other project variables on startup success. The analysis showed that the CII Planning for Startup model to be a good template for startup planning. Its companion, the SuPER tool score, was shown to have positive correlation with startup success and therefore represents a viable metric for monitoring how well the model is being implemented.

The analysis of management decisions showed there are a variety of ways to manage a successful startup. The startup manager could be assigned to the project as late as the Detail Design phase without affecting the success of the startup. However, when he/she is assigned in the Construction phase a noticeable decrease in startup success was observed.

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The initial assignment of the startup manager, full-time or part-time, was not strongly related to the size of the project. There was some indication that in those projects where the assignment was full-time, the startup was more successful and had less variability than in those where the initial assignment was a part-time one.

Formal training of the startup manager was infrequent (approximately 30%) and its effect on startup success was unclear.

Startup incentives were considered in nearly half of the projects but not used in any of the projects studied.

The phase of the project when startup systems were identified was shown to affect startup success. Not surprisingly, the earlier they were identified the higher the level of startup success. Projects where the systems were identified during the Front-End Engineering (the phase recommended in the model), had the highest levels of startup success and the smallest range of variability.

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Chapter 7 Conclusions and Recommendations

In this final chapter a summary of the conclusions and recommendations of the research are presented. This summary is presented in the context of the research objectives that were to:

- Validate the Construction Industry Institute's model: Planning for Startup
- Identify model activities that were significantly related to startup success
- Identify management activities that contribute to model implementation or startup success.

7.1 CONCLUSIONS

7.1.1 Validity of the Planning for Startup Model

1. Measuring Startup Success. The research demonstrated that an index could be used to reliably measure startup success and that it is statistically related to the overall success of the project. For the project sample, the weighting factors for the eight success parameters were approximately the same suggesting all were of approximately equal importance.
2. Model Validity. Based upon analysis of this sample data, CII's Planning for Startup model is a relevant and meaningful model for planning a startup. Additionally, the research demonstrated that the SuPER tool is a good indicator of model implementation and statistically showed that higher SuPER scores (i.e. higher levels of model implementation) are

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related to higher levels of startup success. While it is not surprising that more startup planning leads to greater level of success, the results confirmed that planning efforts based on the activities in the CII Planning for Startup model are positively correlated with successful startups.

3. Other project factors affecting startup success. The research also showed that two project factors beside startup planning can have significant impacts on the success of the startup:
   - Process technology. New process technologies had a significant negative effect on startup success. Startup projects with new technologies were less successful than those projects using a mature process.
   - External Factors. When present, external factors such as labor contract disputes had a significant effect on startup success.
4. Project factors not affecting startup success. Given the limitation of the data sample, the research also demonstrated that startup success is not statistically related to these project variables:
   - Total Installed Cost of the project,
   - Site Characteristics (i.e. grass roots or retrofit)

7.1.2 Significant Activities in the Planning for Startup Model

Eighteen model activities were found to be significantly correlated with either the level of the planning effort or the phase (timing) of activity initiation.

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Startup success was found to be less affected by planning effort than planning timing and only five model activities were identified as effort-sensitive:

- 2-A: Seek a Realistic Forecast of Startup Duration
- 2-B: Estimate Startup Costs
- 3-A: Establish Startup Objectives
- 6-D: Conduct Operator/Maintenance Training
- 8-D: Finalize Documentation

The phase of initiation was shown to have a greater effect on startup success as 13 model activities were found to be significantly related to startup success. Of note is that all of these phase-sensitive activities were confined to the Front-End Engineering, Design Engineering or Construction phases.

- 3-C: Make Startup Team Assignments
- 3-D: Identify Startup Systems
- 3-E: Acquire Operations & Maintenance Input
- 3-F: Assess Startup Risks
- 3-G: Analyze Startup Incentives
- 4-A: Address Startup Issues In Team-Building Sessions
- 4-B: Assess & Communicate Startup Effects From Changes
- 4-C: Plan For Supplier Field Support
- 4-E: Plan For Startup QA/QC
- 4-L: Develop System Turnover Plan

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- 4-M: Develop And Communicate Startup Procedures And Process Safety Management

- 6-B: Conduct Construction-Startup Team Building

- 6-G: Transition To Startup Systems-Based Execution

7.1.3 Startup Management Activities

The last area of research was to assess and identify management activities that contribute to model implementation or startup success. The objective of this analysis was to provide guidance to owners and project managers on the timing, training, and budgeting for startup. A summary of these findings is presented below.

1. Startup Budgeting and Cost Tracking. All of the projects had a startup budget but only one used it as a project control parameter. Most projects (89%) tracked startup costs but there was little consistency in tracking methods. Nearly half (46%) of the companies surveyed did not have a uniformly applied method for tracking startup costs.
2. Assigning the Startup Manager: Phase and Commitment. In this sample, the projects that appointed the startup manager in the construction phase had the lowest median Startup Success Index scores. Projects that made the initial commitment of the startup manager a full-time one were more successful than in those for that made the initial commitment a part-time one.

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3. Identification of Systems. The earlier systems are identified, the higher the startup success scores. Twenty eight percent (28%) of the projects had systems identified in the Front-End Engineering phase, i.e. the phase recommended in the Planning for Startup model. These projects had the highest median success score in the sample.

7.2 RECOMMENDATIONS

7.2.1 Industry

The CII Planning for Startup Model was shown to be significantly correlated to startup success and is applicable for a wide range of industry types including the pharmaceutical, power, and chemical industries.

The model can benefit both existing companies and new ones. Companies with established procedures could benefit by incorporating selected elements of the startup planning model into established processes. For new companies needing to develop startup guidelines the model represents an excellent starting point.

To assists companies wishing to implement the Planning for Startup model the following recommendations are offered:

- Invest the effort to develop a realistic forecast of the startup duration. Failure to do so during the early stages of the project jeopardizes the accuracy of estimate and affects the overall accuracy of the project's commercial operations date.

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- Develop a consistent cost control plan for estimating and tracking startup costs. At an industry average of 5.5% of construction cost, startup costs represent a significant portion of the project's budget.
- Assign a full-time Startup Manager as early as possibly but no later than the Detail Design phase of the project.
- Identify startup systems no later than the Front-End Engineering phase of the project.
- For projects with new process technologies, begin operator and training programs as early as possible.

The research also reinforced the importance of recognizing that projects are not executed in a vacuum. The regulatory and social environment of the region significantly affects major projects. This interaction must be recognized early and addressed adequately to avoid significant delays to the startup of the project.

7.2.2 Future Research

Future research into the area of startup planning should be expanded to include more definitive metrics for assessing the effects of new process technology, identifying the presence of significant regulatory externalities and measuring the effect of management experience.

A better understanding of why some regulatory externalities can be so devastating is needed. Most of the projects in this sample had regulatory requirements and most of them were reasonably successful. But when an

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unexpected external regulatory factor is present, it became the dominant factor in the outcome of the project. A better understanding of this phenomena and the project conditions that foster its development are needed.

The analysis showed that the project manager's years of experience was found to be significant in predicting startup success. Although years of experience was shown to be statistically valid, there is evidence suggesting this conclusion to be misleading. More specific information is needed to accurately assess the relationship between experience and success.

In conclusion, the CII Planning for Startup Model is an effective tool for successful startup planning. The model will not eliminate the difficulty and risk involved in the startup process, nor will it change the effects of process complexity or regulatory externalities on startup success. What the model can do, as shown in this research, is enhance the probability of startup success. For this reason, it represents an important contribution to the planning and execution of process industry capital facility projects.

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Appendix A: Model Activity Id – Interview Guide Cross Tabulation

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A.1 MODEL ID-INTERVIEW GUIDE CROSS TABULATION TABLE

Presented below is a Cross-Tab table-relating Model ID to the Interview Guide Section V Questions. Notes: 1) A 99 indicates Model ID without Interview Guide Question.

Model ID	Interview Guide Question	Activity
1-A	1	Ensure Senior Management Commitment to Integrated Startup Planning and Needed Resources
2-A	2	Seek a Realistic Forecast of Startup Duration
2-B	3	Estimate Startup Costs
2-C	4	Recognize the Impact of Startup on Project Economics
3A	5	Establish Startup Objectives
3-B	6	Develop the Startup Execution Plan
3-C	7	Make Startup Team Assignments
3-D	8	Identify Startup Systems
3-I	9	Refine Startup Budget & Schedule
3-E	10	Acquire Operations & Maintenance Input
3-F	11	Assess Startup Risks
3-H	12	Identify Startup Procurement Requirements
3-G	13	Analyze Startup Incentives
4-A	14	Address Startup Issues in Team-Building Sessions
4-D	15	Include Startup in the Project CPM Schedule
4-C	17	Plan for Supplier Field Support of Startup
4-E	18	Plan for Startup QA/QC

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A.1 Model ID-Interview Guide Cross Tabulation Table (Cont'd)

Model ID	Interview Guide Question	Activity
4-H	19	Indicate Startup System Numbers on Engineering Deliverables
4-J	20	Plan Operator/Maintenance Training
4-K:	21	Develop Startup Spare Parts Plan
4-F	22	Refine the Startup Team Organization Plan and Responsibility Assignments
4-B	23	Assess & Communicate Startup Effects from Changes
4-M	24	Develop and Communicate Startup Procedures and Process Safety Management
4-L	25	Develop System Turnover Plan
6-G	27	Transition to Startup Systems-Based Execution:
6-B	28	Conduct Construction-Startup Team Building
6-D	29	Conduct Operator/Maintenance Training
8-D	32	Finalize Documentation
3-J	99	Update the Startup Execution Plan
4-G	99	Acquire Additional O&M Input
4-I	99	Refine Startup Risk Assessment
4-N	99	Refine Startup Budget and Schedule
4-O	99	Update the Startup Execution Plan
5-A	99	Qualify Suppliers for Startup Services
5-B	99	Refine the Startup Spare Parts Plan and Expedite

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A.1 Model-Interview Guide Cross Tabulation Table (Cont'd)

Model ID	Interview Guide Question	Activity
5-C	99	Implement the Procurement QA/QC Plan
6-A	99	Finalize the Startup Execution Plan
6-C	99	Refine the Startup Integrated CPM
6-E	99	Implement the Field QA/QC Plan
6-F	99	Finalize the Startup Risk Assessment
7-A	99	Finalize the Operations & Maintenance Organization and Management Systems
7-B	99	Check-Out Systems:
7-C	99	Commission Systems
8-A	99	Plan Initial Operations
8-B	99	Introduce Feedstocks
8-C	99	Conduct Performance Testing

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Appendix B: Data Collection Instruments

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B.1 Interview Guide

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CII Planning for Start-Up Research Team

INTERVIEW GUIDE

Mar-96

NOTE: THE INTERVIEWERS WILL KEEP ALL INFORMATION STRICTLY CONFIDENTIAL.

NO PUBLISHED STATISTICS OR COMMENTS WILL EVER BE ASSOCIATED WITH ANY NAMED ORGANIZATION OR INDIVIDUAL.

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I. INTERVIEWEE INFO & CORPORATE PRACTICES

Interview Date/Place: A.

B.1st Interviewee:

Name:	Company:
Address:	
Phone:	Fax:
Title/Relationship to Job or Company:	
Total years of industry experience:	Years with company:

C.2nd Interviewee:

Name:	Company:
Address:	
Phone:	Fax:
Title/Relationship to Job or Company:	
Total years of industry experience:	Years with company:

D.3rd Interviewee:

Name:	Company:
Address:	
Phone:	Fax:
Title/Relationship to Job or Company:	
Total years of industry experience:	Years with company:

II. IDENTIFICATION OF START-UPS FOR IN-DEPTH ANALYSIS

Project Name	**Location**	**Owner**	**Year SU Compltd**	**$ TIC**	**Contract Form**
A	B	C	D	E	F Lump sum vs. Cost+ G EPC vs. multipl contr.

Type of project. Please circle all that apply

H chemical, food, manufactur'g, metals, petro. refining, pharmaceut'l, power, pulp/paper, textiles

I capital/grass roots, revamp/retrofit, maintenance

J mature process technology, new process technology

Number of work shifts during SU? K

Maximum manloading during SU? L

Comments regarding continuity of key project personnel?

M

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What types of projects have you been heavily involved in over the last 10-15 years? Please circle all that apply

E. chemical, food, manufactur'g, metals, petro. refining, pharmaceut'l, power, pulp/paper, textiles

F. capital/grass roots, revamp/retrofit, maintenance

G. mature technology, new technology

This research will draw from your experience history. Approximately how many projects (over $500K) have you been involved with or have detailed, first-hand experience with?

H.

Please show or discuss your typical project organization chart (with defined titles)

I. attached/ will send/ not available

J

Does your company employ any SU PLANNING TOOLS (e.g., procedures, flow charts, check

K yes/no

Can you share these with us?

L attached/ will send/ not available/ don't exist

If not, please discuss what tools are available. Are they useful? Are they commonly used?

M

What are the initial and final milestones of the SU phase within your company?

Initial milestone: N

Final milestone: O

Are these generally well-defined or understood?

P yes/ no

Do you in any way track StartUp costs? If so, how? Is your approach particularly effective or useful?

Q

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Regarding the Project being analyzed....

III. SU SUCCESS RATINGS, PERCENTILES, & FACTORS

Please review the MEASURES OF SU SUCCESS listed below and add any missing items that you believe are significant.

Then, rate each item for their RELATIVE IMPORTANCE to the success of the SU on THIS PROJECT.

Were these SU objectives FORMALLY established for THIS project?

Measure of StartUp Success	**Relative Importance on THIS Project**	**Was this SU objective formally established?**
	0=no importance 5=critically important	
1 SU safety performance .... *(frequency/severity of accidents, injuries, ...)*	C	yes/ no L
2 SU environmental performance .... (frequency/severity of spills, releases, emissions, etc.)	D	yes/ no M
3 Quality of produced product	E	yes/ no N
4 Quantity rate of produced product	F	yes/ no O
5 SU schedule performance .... (meeting milestone objectives)	G	yes/ no P
6 Minimal impact/disruptions to ongoing operations	H	yes/ no Q
7 Achieve a high performance operations team	I	yes/ no R
A	J	yes/ no S
B	K	yes/ no T

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To what extent did you ACHIEVE the following SU objectives?

Measure of StartUp Success	Degree of Achievement 0=did not achieve objective; 5=fully achieved objective
1 SU safety performance .... (frequency/severity of accidents, injuries, ...)	CC
2 SU environmental performance .... (frequency/severity of spills, releases, emissions, etc.)	DD
3 Quality of produced product	EE
4 Quantity rate of produced product	FF
5 SU schedule performance .... *(meeting milestone objectives)*	GG
6 Minimal impact/disruptions to ongoing operations	HH
7 Achieve a high performance operations team	II
AA	JJ
BB	KK

START-UP

Success Percentile	Start-up Causal Factors
L %	M

Proj. TECHNICAL Success Percentile	Technical Causal Factors	Proj. COMMERCIAL Success Percentile	Commercial Causal Factors
N %	O	P %	Q

IV. DURATION & SCHEDULE ANALYSIS

OVERALL PROJECT Duration (mo)	PLANNED SU Duration at Appr. Req. (wk)	ACTUAL StartUp Duration (wk)	Schedule Causal Factors
A	B	C	D

Did you or the contractor develop a detailed CPM schedule (with network logic) for SU?

E

Was it adequately detailed? Was it resource loaded?

F yes/ no G yes/ no

Was it fully integrated with the Project Schedule?

H yes/ no

Who (what position) established the SU duration at the Appropriation Request stage?

I

General: What tools or procedures do you use to track the PHYSICAL COMPLETION OF CONSTRUCTION of the various SU systems? How effective are they?

J

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V. ASSESSMENT OF SU PLANNING ACTIVITIES

A Please review the Start-Up Planning Model on the next two pages and assess your practice on this project.

format for doing this?

B

General: Are SU systems ever FORMALLY integrated with process control systems? If so, when does this occur?

C

Planning For Startup Model

This Project:________________

#	Start-Up Planning Activity	0-5 scale To What Extent Was It DoneOn This Proj.?	When did it happen on this project? (xx all that apply)								0-5 scale Perciev'd Significac To ANY Project
			Reqmts. Definit'n	Feasblty Concept Develmt	Front End Engrg.	Detld Design & Procmt	Constr. & Test'g	Pro-Op'l Test'g & Comm'g	Initial Operns	Comm'l Operns	
1	Ensure Sr. Mgmt commitment to SU planning										
2	Seek a realistic forecast of SU duration										
3	Estimate SU costs										
4	Recognize the impact of SU on proj economics										
5	Establish SU objectives										
6	Develop the SU strategy & execution plan										
7	Make the SU team assignments										
8	Identify SU systems										
9	Refine the SU budget & schedule										
10	Acquire O&M input										
11	Assess SU risks										
12	Identify SU procurement requirements										
13	Analyze SU incentives										
14	Address SU issues in team building sessions										
15	Include SU in the project CPM schedule										
16	Plan for O&M review of engineering deliverables										
17	Plan for supplier field support of startup										
18	Scope pre-shipment testing & QA/QC										
19	Indicate SU system # on engineering deliverables										
20	Develop operator training plan										
21	Develop a SU spare parts plan										
22	Validate SU priorities & sequence										
23	Assess & communicate SU effects from changes										
24	Estab SU procedures/Process Safety Mgt										
25	Develop system turnover plan										

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This Project:____________________

#	Start-Up Planning Activity	0-5 scale To What Extent Was It DoneOn This Proj.?	When did it happen on this project? (xx all that apply)								0-5 scale Perciev'd Significnc To ANY Project
			Reqmts Definit'n	Feasbity Concept Develmt	Front End Engrg.	Detld Design & Procmt	Constr. & Test'g	Pro-Op'l Test'g & Comm'g	Initial Operns	Comm'l Operns	
26	Acquire spare parts										
27	Transition to systems-based execution										
28	Conduct constr.-SU team building										
29	Conduct operator training										
30	Procedures for SU problem ID & resolutn										
31	Document SU lessons learned										
32	SU performance measures & final report										
33	SU performance feedback to Sr. mgmt										
34											

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IX. LESSONS LEARNED

General: *What types of systems or subsystems are most problematic in the SU process? Why?*

A

General: *Have you had any challenging SUs where you overcame significant risks? Please elaborate.*

B

General: Please discuss LESSONS LEARNED from both successful and unsuccessful SUs. Think of previous SU delays, change orders, safety or environmental problems, or claims. Discuss causal factors, innovative solutions, and any measured effects.

C

B.2 PROJECT SUCCESS FOLLOW-UP QUESTIONNAIRE

CII SU Research Team
Follow-Up Questionnaire

Project Success

Purpose of Questionnaire

In this survey we are attempting to quantify the overall success of the project and the relative importance of the success variables.

Instructions for Completing Questionnaire:

1. Instructions for survey completion are self explanatory: Just go down the list, read each question and check the appropriate box. If you have any questions call :
   - John McLeod/512.471.1620 or
   - Dr. Jim O'Connor/512.471.4921

Project Information

1. Project Name:

2. Interviewee Perspective

Of the three categories listed below which one best represents your perspective of the Project.

☐ Business Unit (Project Initiator, Investor, Sr. Mgmt etc.)

☐ Project Team (Project Manager, Constructor, Designer, SU manager etc.) responsible for delivering an operational facility in accordance with the authorization goals for the project.

☐ Manufacturing (Operations, Maintenance, Facility Engineering). The group responsible for commercial operations of the completed project

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Assessment of Project Success Variables
For the Success Variable Question please indicate the level of project performance

Success Variable	Question	Performance
COST PERFORMANCE	*The Total Installed Cost for the Project was ....*	☐ Significantly Under Authorized Budget. ☐ Essentially At Authorized Budget ☐ Significantly Over Authorized Budget
SCHEDULE PERFORMANCE	*The actual Commercial Operations Start date was ....*	☐ Significantly earlier than Planned at Authorization ☐ Essentially at the Planned start Date ☐ Significantly later than Planned at Authorization
	How did construction completion (i.e. ready for commissioning) affect the overall project duration ?	☐ Reduced overall project duration. ☐ No Effect on project duration. ☐ Increased overall project duration.
	How did design completion affect the overall project duration?	☐ Reduced overall project duration ☐ No Effect. on project duration ☐ Increased overall project duration

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Success Variable	**Question**	**Performance**
	At what % of Detail Design did field construction begin?	% ________________
DEMONSTRATION OF DESIGN CAPACITY	*What % of Design Capacity was demonstrated?*	☐ Significantly over 100% of Design Capacity ☐ Essentially 100% of Design Capacity ☐ Significantly under 100% of Design Capacity
UNSCHEDULED DOWN-TIME	*During the first 4 to 6 months of operations, the % of unscheduled down-time was ....*	☐ Significantly below expectations. ☐ As expected for similar projects ☐ Significantly greater than expected
PROJECT SAFETY	*Were there any OSHA reportable injuries during the project ?*	☐ Yes ☐ No
ENVIRONMENTAL	*Were there any reportable releases or spills during the project?*	☐ Yes ☐ No
OPERATING COSTS	*After 4-6 months of operations, the operating cost of the facility was ...*	☐ A Problem ☐ Not a Problem ☐ Don't Know

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Importance Factors for Success Variables

At the time of Project Authorization, what was the relative importance of the following success variables?

Variable	Most Important	Above Average Importance	Average Importance	Below Average Importance	Least Important
COST PERFORMANCE	☐	☐	☐	☐	☐
SCHEDULE PERFORMANCE	☐	☐	☐	☐	☐
DEMONSTRATION OF DESIGN CAPACITY	☐	☐	☐	☐	☐
UNSCHEDULED DOWNTIME	☐	☐	☐	☐	☐
PROJECT SAFETY	☐	☐	☐	☐	☐
ENVIRONMENTAL	☐	☐	☐	☐	☐
OPERATING COSTS	☐	☐	☐	☐	☐

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B.3 STARTUP SUCCESS FOLLOW-UP QUESTIONNAIRE

CII Start Up Research Team
Follow-Up Questionnaire

Start Up Success

Purpose of Questionnaire

In this survey we are attempting to quantify the level of Start Up success based upon your level of satisfaction with the Start Up indicators defined in the questionnaire..

Instructions for Completing Questionnaire:

1. Instructions for survey completion are self-explanatory: Just go down the list, read each question and check the appropriate box. If you have any questions call :
   - John McLeod/512.471.1620 or;
   - Dr. Jim O'Connor/512.471.4921

Project Information

1. Project Name:

2. Interviewee Perspective

Of the three categories listed below, which one best represents your perspective of the start up phase of the project.

☐ Business Unit (Project Initiator, Investor, Sr. Mgmt. etc.)

☐ Project Team (Project Manager, Constructor, Designer, SU manager etc.) responsible for delivering an operational facility in accordance with the authorization goals for the project.

☐ Manufacturing (Operations, Maintenance, Facility Engineering). The group responsible for commercial operations of the completed project.

Start Up Controls Information

1. Do you track and monitor SU costs ?

☐ Yes

☐ No

2. Are Start Up Costs handled uniformly from project to project?

☐ Yes

☐ No

3. On what percent of projects do you involve the Constructor in Start Up? ______________%

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Start Up Success Indicators

For each of the Start Up success indicators listed below, please indicate your level of satisfaction.

1. Product Quality Performance
At the end of Start Up, what was your satisfaction level with product quality as established at project authorization?

Satisfaction Level	Definition
☐ Extremely Satisfied	Product quality consistently exceeded project goals.
☐ Very Satisfied	Product quality goals were consistently met..
☐ Satisfied	Product quality goals were met with expected amounts of off-spec material.
☐ Dissatisfied	Product quality met specification most of the time but the amount of off-spec material was higher than expected.
☐ Very Dissatisfied	Product quality was met only with significant process and construction rework.

2. Product Quantity Performance
At the end of Start Up, what was your satisfaction level with production quantity as established at project authorization?

Satisfaction Level	Definition
☐ Extremely Satisfied	Production rates consistently exceeded project goals
☐ Very Satisfied	Production rates met project goals.
☐ Satisfied	Production rates were marginally less than planned but customers were not affected.
☐ Dissatisfied	Plant did not met production rates set at project authorization.
☐ Very Dissatisfied	Production rates were significantly lower than planned and required significant construction rework.

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3. Schedule Performance

What was your level of satisfaction with the Start Up duration as compared with the duration set at project authorization ?

Satisfaction Level	Definition
☐ Extremely Satisfied	The Start Up duration was significantly less than estimated. The process was up and on-line much sooner than expected.
☐ Very Satisfied	The Start Up duration was as planned.
☐ Satisfied	The Start Up duration was as planned but meeting the schedule required extra levels of labor and/or materials .
☐ Dissatisfied	The Start Up duration exceeded plan and meeting the schedule required heroic efforts on the part of the Start Up Team.
☐ Very Dissatisfied	The Start Up duration far exceeded the original plan.

4. Safety Performance

Which best describes your level of satisfaction in regards to safety during the Start Up phase of the project?

Satisfaction Level	Definition
☐ Extremely Satisfied	The Start Up had no reportable injuries and no incidents requiring any type of medical attention
☐ Very Satisfied	The Start Up had no reportable incidents and only a minor number of incidents requiring some type of medical attention.
☐ Satisfied	The Start Up had no reportable incidents and a typical number of minor first aid type incidents.
☐ Dissatisfied	The Start Up had one or more reportable incidents or a higher number of minor and preventable medical incidents.
☐ Very Dissatisfied	The Start Up had one or more lost-time incidents.

5. Environmental Performance

Were there any reportable releases or spills during Start Up?

☐ Yes

☐ No.

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6. Operations Team Performance
Which best describes your level of satisfaction in regards to the effectiveness of the Operations Team during Start Up?

Satisfaction Level	Definition
☐ Extremely Satisfied	Operations Team was thoroughly prepared for plant operations challenges.
☐ Very Satisfied	Operations Team was more than adequately prepared for plant operations challenges.
☐ Satisfied	Operations Team was prepared for plant operations.
☐ Dissatisfied	Operations Team was not prepared for plant operations and required additional, unplanned, training.
☐ Very Unsatisfied	Operations Team was not prepared for plant operations. They required a significant amount of additional, unplanned, training which resulted in delays and additional Start Up technical support.

7. Impact on On-going Operations
Which best describes your level of satisfaction in regards to the effect of Start Up activities on existing operations?

Satisfaction Level	Definition
☐ N/A	There were no other facilities to impact.
☐ Extremely Satisfied	There was no impact on on-going operations.
☐ Very Satisfied	There was minimal impact on on-going operations
☐ Satisfied	There were no unanticipated impacts on on-going operations
☐ Dissatisfied	On-going operations were impacted.
☐ Very Unsatisfied	On-going operations were significantly impacted

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8. Level of Effort Required by the Start Up Team

Which best describes how the actual level of Start Up effort compared to the planned or anticipated level of Start Up effort.

Satisfaction Level	Definition
☐ Extremely Satisfied	Start Up work hours were well below budget. Level of stress was much less than anticipated.
☐ Very Satisfied	Start Up work hours were on budget. Level of stress was less than anticipated.
☐ Satisfied	Start Up work hours were on budget. Level of stress was typical.
☐ Dissatisfied	Start Up work hours were slightly above budget. The level of stress was greater than anticipated.
☐ Very Dissatisfied	Start Up work hours were significantly over budget. The level of stress was significantly greater than anticipated.

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Importance Factors for Start Up Success Indicators

At the time of Project Authorization, what was the relative importance of the following success variables?

Indicator	Most Important	Above Average Importance	Average Importance	Below Average Importance	Least Important
PRODUCT QUALITY	☐	☐	☐	☐	☐
PRODUCT QUANTITY	☐	☐	☐	☐	☐
SCHEDULE PERFORMANCE	☐	☐	☐	☐	☐
SAFETY PERFORMANCE	☐	☐	☐	☐	☐
ENVIRON-MENTAL PERFORMANCE	☐	☐	☐	☐	☐
OPERATIONS TEAM PERFORMANCE	☐	☐	☐	☐	☐
IMPACT ON ON-GOING OPERATIONS	☐	☐	☐	☐	☐
LEVEL OF EFFORT BY START UP TEAM	☐	☐	☐	☐	☐

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B.4 THE SUPER TOOL

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CII SUPER TOOL: Startup Planning Evaluation Rating vers. 2.0

Sheet 1 of 2

Project:

Evaluator: Date:

Act No.	Planning Activity	No Execution	Minimal Effort	With Deficiencies	With Minor Deficiencies	Thoroughly Executed	Score
1-A	Ensure senior management commitment to SU	0	1	3	4	5	
2-A	Seek a realistic forecast of Startup duration	0	0	1	3	4	
2-B	Estimate Startup costs	0	0	1	1	1	
2-C	Recognize the impact of Startup on project ecc	0	1	3	4	5	
	Definition, Concept, & Feasibility Phase Total	0	2	8	12	15	
3-A	Establish Startup objectives	0	1	2	4	5	
3-B	Develop the Startup Execution Plan	0	1	3	4	5	
3-C	Make the Startup team assignments	0	0	1	2	3	
3-D	Identify Startup systems	0	1	3	4	5	
3-E	Acquire Operations & Maintenance input	0	0	1	3	4	
3-F	Assess Startup risks	0	1	1	2	2	
3-G	Analyze Startup incentives	0	0	1	1	1	
3-H	Identify Startup procurement requirements	0	1	1	2	2	
3-I 4-N	Refine/update the Startup budget & schedule	0	0	1	1	1	
3-J 4-O 6-A	Update the Startup Execution Plan	0	1	3	4	5	
	Front End Engineering Phase Total	0	6	17	27	33	
						Total This Sheet:	

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CII SUPER TOOL: *Startup Planning Evaluation Rating* vers. 1.0 **Sheet 2 of 2**

Act. No.	Planning Activity	No Execution	Minimal Effort	With Deficiencies	With Minor Deficiencies	Thoroughly Executed	Score
4-A	Address Startup issues in team building sessi	0	0	1	1	1	
4-B	Assess & communicate Startup effects from cl	0	0	1	1	1	
4-C	Plan for supplier field support of Startup	0	0	1	2	2	
4-D	Include Startup in the project CPM schedule	0	1	2	3	4	
4-E	Plan for Startup QA/QC	0	0	1	1	1	
4-F	*Refine Startup team organiz'n & respons'b'ty a*	*0*	*0*	*1*	*3*	*4*	
4-G	Acquire additional O&M input	0	1	2	2	3	
4-H	Indicate Startup system numbers on engr. deli	0	1	2	2	3	
4-I 6-F	Refine/update Startup risk assessment	0	1	1	2	2	
4-J	Plan operator/maintenance training	0	1	2	3	4	
4-K	Develop Startup spare parts plan	0	0	1	1	1	
4-L	Develop system turnover plan	0	0	1	3	4	
4-M	Develop & communicate Startup procedures &	0	0	1	3	4	
5-A	Qualify suppliers for Startup services	0	0	1	1	1	
5-B	Refine/update Startup spare parts plan & expe	0	0	1	1	1	
5-C	Implement procurement QA/QC plan	0	0	1	1	1	
	Detailed Design & Procurement Phase Total	**0**	**5**	**20**	**30**	**37**	☐
6-B	Conduct Construction-Startup team building	0	0	1	1	1	
6-C	*Refine/update Startup integrated CPM schedul*	0	1	2	3	4	
6-D	Conduct operator/maintenance training	0	0	1	3	4	
6-E	Implement field QA/QC plan	0	0	1	1	1	
6-G	Transition to Startup systems-based execution	0	1	3	4	5	
	Construction Phase Total	**0**	**2**	**8**	**12**	**15**	☐
	Maximum Total: All Phases	**0**	**16**	**60**	**81**	**100**	

Total This Sheet: ☐

Total Sheet 1: ☐

GRAND TOTAL: ☐

B.5 STARTUP SUCCESS INDEX CALCULATIONS

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SU Success Index Calculations

	Product Quality				Product Quantity				Schedule Performance			
	Peformance	Importance	Scores		Performance	Importance	Scores		Performance	Importance		Scores
ProjectID			Actual	Maximun			Actual	Maximun			Actual	Maximun
P-03	1	4	4	20	1	5	5	25	1	5	5	25
P-04	4	5	20	25	4	4	16	20	5	5	25	25
P-06	4	4	16	20	4	4	16	20	3	4	12	20
P-08	5	3	15	15	4	5	20	25	5	5	25	25
P-09	3	4	12	20	4	4	16	20	3	5	15	25
P-10	4	3	12	15	4	4	16	20	5	4	20	20
P-11	3	3	9	15	3	3	9	15	5	4	20	20
P-12	5	4	20	20	5	3	15	15	3	5	15	25
P-13	1	4	4	20	3	3	9	15	2	5	10	25
P-14	4	5	20	25	5	5	25	25	4	4	16	20
P-15	3	5	15	25	3	3	9	15	2	4	8	20
P-16	4	4	16	20	4	4	16	20	5	5	25	25
P-17	5	5	25	25	5	5	25	25	5	5	25	25
P-18	2	5	10	25	1	5	5	25	1	4	4	20
P-19	4	5	20	25	5	2	10	10	4	5	20	25
P-20	5	5	25	25	5	5	25	25	4	3	12	15
P-21	1	5	5	25	4	5	20	25	2	3	6	15
P-22	3	4	12	20	3	4	12	20	3	5	15	25
P-23	4	4	16	20	4	3	12	15	4	4	16	20
P-24	3	4	12	20	5	5	25	25	4	5	20	25
P-25	4	3	12	15	4	3	12	15	4	3	12	15
P-26	4	5	20	25	5	4	20	20	2	5	10	25
P-27	5	5	25	25	5	3	15	15	4	2	8	10
P-28	4	5	20	25	2	4	8	20	2	4	8	20
P-29	2	4	8	20	2	4	8	20	2	5	10	25
P-30	4	4	16	20	4	5	20	25	3	4	12	20
Number of Projects =		26										

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SU Success Index Calculations

	Safety Performance				Environmental Performance				Operations Team Performance			
	Performance	Importance	Scores		Performance	Importance	Scores		Performance	Importance	Scores	
Projec Id			Actual	Maximun			Actual	Maximun			Actual	Maximun
P-03	4	5	20	25	1	4	4	20	4	3	12	15
P-04	5	5	25	25	5	5	25	25	5	5	25	25
P-06	5	4	20	20	5	4	20	20	3	3	9	15
P-08	4	5	20	25	5	5	25	25	3	4	12	20
P-09	5	5	25	25	5	3	15	15	3	2	6	10
P-10	5	5	25	25	5	5	25	25	4	4	16	20
P-11	3	3	9	15	0	3	0	15	2	2	4	10
P-12	4	3	12	15	5	3	15	15	4	4	16	20
P-13	5	5	25	25	5	3	15	15	2	3	6	15
P-14	4	4	16	20	5	3	15	15	4	4	16	20
P-15	3	5	15	25	1	4	4	20	2	4	8	20
P-16	5	5	25	25	5	5	25	25	5	5	25	25
P-17	5	5	25	25	5	4	20	20	5	5	25	25
P-18	5	5	25	25	1	5	5	25	2	4	8	20
P-19	5	5	25	25	5	3	15	15	3	4	12	20
P-20	2	5	10	25	5	5	25	25	5	4	20	20
P-21	2	5	10	25	1	5	5	25	2	4	8	20
P-22	5	5	25	25	5	4	20	20	3	3	9	15
P-23	4	4	16	20	5	4	20	20	4	4	16	20
P-24	4	5	20	25	5	4	20	20	5	4	20	20
P-25	5	5	25	25	1	5	5	25	4	3	12	15
P-26	5	4	20	20	1	4	4	20	4	5	20	25
P-27	4	5	20	25	5	3	15	15	4	4	16	20
P-28	4	2	8	10	5	2	10	10	4	4	16	20
P-29	2	4	8	20	0	4	0	20	1	4	4	20
P-30	5	4	20	20	5	4	20	20	4	3	12	15

SU Success Index Calculations

Impact on On-going Operations				Level of Effort by Start Up Team							
Performance	Importance	Scores		Performance	Importance	Scores		Totals			
		Actual	Maximun			Actual	Maximun	Actual	Maximun	SU SUCCESS INDEX	Project ID
1	5	5	25	1	3	3	15	58	170	0.34	P-03
0	1	0	5	5	5	25	25	161	175	0.92	P-04
4	2	8	10	4	3	12	15	113	140	0.81	P-06
0	1	0	5	1	5	5	25	122	165	0.74	P-08
0	0	0	0	3	2	6	10	95	125	0.76	P-09
5	5	25	25	4	4	16	20	155	170	0.91	P-10
3	3	9	15	4	3	12	15	72	120	0.60	P-11
4	5	20	25	3	3	9	15	122	150	0.81	P-12
4	5	20	25	1	3	3	15	92	155	0.59	P-13
5	5	25	25	3	4	12	20	145	170	0.85	P-14
0	0	0	0	1	4	4	20	63	145	0.43	P-15
4	5	20	25	4	4	16	20	168	185	0.91	P-16
5	3	15	15	5	4	20	20	180	180	1.00	P-17
1	5	5	25	1	4	4	20	66	185	0.36	P-18
5	4	20	20	4	4	16	20	138	160	0.86	P-19
0	0	0	0	4	4	16	20	133	155	0.86	P-20
2	4	8	20	1	4	4	20	66	175	0.38	P-21
4	5	20	25	3	4	12	20	125	170	0.74	P-22
4	2	8	10	3	4	12	20	116	145	0.80	P-23
0	1	0	5	3	2	6	10	123	150	0.82	P-24
5	5	25	25	3	3	9	15	112	150	0.75	P-25
5	4	20	20	1	5	5	25	119	180	0.66	P-26
0	0	0	0	5	3	15	15	114	125	0.91	P-27
4	5	20	25	2	4	8	20	98	150	0.65	P-28
2	5	10	25	1	4	4	20	52	170	0.31	P-29
3	3	9	15	3	3	9	15	118	150	0.79	P-30
									n=	26	

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B.6 PROJECT SUCCESS INDEX CALCULATIONS

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Project Success Index Calculations

	Cost				Schedule				Design Capacity			
	Peformance	Importance	Scores		Performance	Importance	Scores		Performance	Importance		Scores
ProjectID			Actual	Maximun			Actual	Maximun			Actual	Maximun
P-03	3	4	12	20	3	5	15	25	3	4	12	20
P-04	3	5	15	25	3	4	12	20	3	5	15	25
P-06	3	4	12	20	3	4	12	20	3	3	9	15
P-08	5	3	15	15	5	5	25	25	3	5	15	25
P-09	3	4	12	20	3	5	15	25	3	3	9	15
P-10	3	4	12	20	3	4	12	20	3	4	12	20
P-11	1	5	5	25	5	5	25	25	3	5	15	25
P-12	5	4	20	20	3	5	15	25	3	4	12	20
P-13	3	5	15	25	1	5	5	25	3	3	9	15
P-14	5	5	25	25	3	5	15	25	5	5	25	25
P-15	1	4	4	20	3	5	15	25	5	3	15	15
P-16	5	5	25	25	3	4	12	20	3	4	12	20
P-17	1	5	5	25	1	4	4	20	5	4	20	20
P-18	3	5	15	25	1	4	4	20	3	5	15	25
P-19	1	5	5	25	1	5	5	25	3	2	6	10
P-20	3	3	9	15	3	3	9	15	5	5	25	25
P-21	3	3	9	15	1	3	3	15	3	5	15	25
P-22	3	5	15	25	3	5	15	25	1	3	3	15
P-23	3	3	9	15	3	5	15	25	3	3	9	15
P-24	5	4	20	20	5	5	25	25	5	4	20	20
P-25	5	5	25	25	3	3	9	15	3	3	9	15
P-26	3	5	15	25	1	5	5	25	5	4	20	20
P-27	5	4	20	20	1	2	2	10	3	3	9	15
P-28	3	4	12	20	1	5	5	25	3	4	12	20
P-29	5	5	25	25	1	4	4	20	5	3	15	15
P-30	3	3	9	15	3	4	12	20	3	5	15	25
Number of Projects =		26										

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Project Success Index Calculations

	Unschedule Downtime				Safety				Environmental			
	Performance	Importance	Scores		Performance	Importance	Scores		Performance	Importance	Scores	
ProjectID			Actual	Maximun			Actual	Maximun			Actual	Maximun
P-03	3	5	15	25	1	5	5	25	5	4	20	20
P-04	5	3	15	15	1	5	5	25	5	5	25	25
P-06	3	3	9	15	5	4	20	20	5	4	20	20
P-08	3	4	12	20	5	5	25	25	5	5	25	25
P-09	5	3	15	15	5	5	25	25	5	3	15	15
P-10	3	4	12	20	5	5	25	25	5	5	25	25
P-11	3	3	9	15	1	4	4	20	5	3	15	15
P-12	5	4	20	20	5	3	15	15	5	3	15	15
P-13	1	1	1	5	5	5	25	25	5	3	15	15
P-14	5	5	25	25	5	4	20	20	5	3	15	15
P-15	3	4	12	20	1	5	5	25	1	5	5	25
P-16	5	4	20	20	1	5	5	25	5	5	25	25
P-17	3	3	9	15	1	5	5	25	5	4	20	20
P-18	1	4	4	20	5	5	25	25	1	5	5	25
P-19	5	2	10	10	1	5	5	25	5	3	15	15
P-20	5	3	15	15	5	5	25	25	5	5	25	25
P-21	1	4	4	20	1	5	5	25	5	5	25	25
P-22	5	5	25	25	1	5	5	25	5	4	20	20
P-23	3	4	12	20	1	4	4	20	5	4	20	20
P-24	3	3	9	15	1	5	5	25	5	4	20	20
P-25	3	3	9	15	5	5	25	25	1	5	5	25
P-26	3	3	9	15	5	4	20	20	1	5	5	25
P-27	5	3	15	15	1	5	5	25	5	3	15	15
P-28	0	0	0	0	5	4	20	20	5	2	10	10
P-29	1	4	4	20	0	4	0	20	0	4	0	20
P-30	3	4	12	20	5	4	20	20	5	4	20	20

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Project Success Index Calculations

Operating Costs							
Performance	Importance	Scores		Totals		PROJECT	
		Actual	Maximun	Actual	Maximun	SUCCESS INDEX	ProjectID
1	4	4	20	83	155	0.54	P-03
5	5	25	25	112	160	0.70	P-04
5	3	15	15	97	125	0.78	P-06
5	3	15	15	132	150	0.88	P-08
3	2	6	10	97	125	0.78	P-09
5	3	15	15	113	145	0.78	P-10
5	3	15	15	88	140	0.63	P-11
5	3	15	15	112	130	0.86	P-12
3	3	9	15	79	125	0.63	P-13
5	4	20	20	145	155	0.94	P-14
3	4	12	20	68	150	0.45	P-15
5	4	20	20	119	155	0.77	P-16
5	4	20	20	83	145	0.57	P-17
1	4	4	20	72	160	0.45	P-18
5	2	10	10	56	120	0.47	P-19
5	4	20	20	128	140	0.91	P-20
1	4	4	20	65	145	0.45	P-21
5	2	10	10	93	145	0.64	P-22
5	3	15	15	84	130	0.65	P-23
5	5	25	25	124	150	0.83	P-24
5	5	25	25	107	145	0.74	P-25
5	2	10	10	84	140	0.60	P-26
5	3	15	15	81	115	0.70	P-27
3	3	9	15	68	110	0.62	P-28
3	4	12	20	60	140	0.43	P-29
1	3	3	15	91	135	0.67	P-30

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B.7 STARTUP SUCCESS V. PROJECT SUCCESS INDEX REGRESSION

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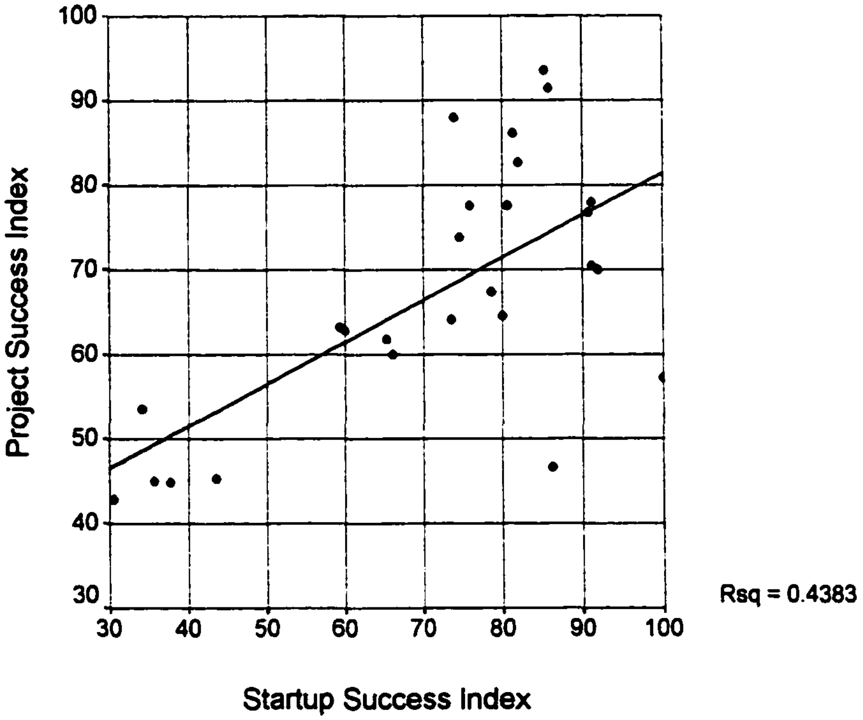
Startup Success Index vs. Project Success Index



Descriptive Statistics

	Mean	Std. Deviation	N
PRJ_INDX	67.1324	15.0999	26
SU_INDX	71.3743	20.0782	26

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Correlations

		PRJ_INDX	SU_INDX
Pearson Correlation	PRJ_INDX	1.000	.662
	SU_INDX	.662	1.000
Sig. (1-tailed)	PRJ_INDX	.	.000
	SU_INDX	.000	.
N	PRJ_INDX	26	26
	SU_INDX	26	26

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	SU_INDX[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: PRJ_INDX

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.662[a]	.438	.415	11.5502

a. Predictors: (Constant), SU_INDX

ANOVA[b]

Model		Sum of Squares	df	Mean Square
1	Regression	2498.427	1	2498.427
	Residual	3201.747	24	133.406
	Total	5700.174	25	

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ANOVA[b]

Model		F	Sig.
1	Regression	18.728	.000[a]
	Residual		
	Total		

a. Predictors: (Constant), SU_INDX

b. Dependent Variable: PRJ_INDX

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	31.595	8.518		3.709	.001
	SU_INDX	.498	.115	.662	4.328	.000

a. Dependent Variable: PRJ_INDX

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B.8 Reliability Analysis for Startup Success Index

```
****** Method 2 (covariance matrix) will be used for this analysis ******

RELIABILITY ANALYSIS - SCALE (CRONBACH'S ALPHA)

1.  ENVIR     Env Index Wt
2.  IMPACT    Imp Index Wt
3.  LOE       LOE Index Wt
4.  OPER      Ops Index Wt
5.  QUAL      Qual Index Wt
6.  QUAN      Quan Index Wt
7.  SAFE      Safe Index Wt
8.  SCHED     Sch Index Wt

                    Mean     Std Dev    Cases

1.  ENVIR           .0908     .0527      26.0
2.  IMPACT          .0696     .0567      26.0
3.  LOE             .0646     .0358      26.0
4.  OPER            .0851     .0366      26.0
5.  QUAL            .0961     .0417      26.0
6.  QUAN            .0952     .0385      26.0
7.  SAFE            .1206     .0392      26.0
8.  SCHED           .0917     .0400      26.0

    N of Cases =    26.0

Item Means        Mean   Minimum  Maximum   Range  Max/Min  Variance
                  .0892   .0646    .1206    .0560  1.8666    .0003

Item Variances    Mean   Minimum  Maximum   Range  Max/Min  Variance
                  .0019   .0013    .0032    .0019  2.5070    .0000

Inter-item
Correlations      Mean   Minimum  Maximum   Range  Max/Min  Variance
                  .2782  -.2188    .6452    .8640  -2.9482   .0691

Reliability Coefficients    8 items

      Alpha =  .7184         Standardized item alpha =  .7551
```

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Appendix C: Data Collection Results

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C.1 SUMMARY DESCRIPTIONS OF SAMPLE STARTUPS

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-03	Chemical	Industrial wastewater treatment plant. Multiple units sent waste to plant for treatment.	New	Regulatory driven project required for the plant complex to obtain a discharge permit. Lack of PM continuity. PM replaced during detail design. Operator sequencing error results in explosion during SU. Design deficiencies result in lower than specified plant capacity requirements. Reduced treatment capacity affects upstream production units necessitating major rework of the treatment plant.	Yes. Environmental regulatory project required for discharge permit.	0.34	79

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-04	Power	Co-gen. plant for electrical and steam production for industrial complex.	Mature	Good Sr. Mgmt support of project. Project identified as a "benchmark" project for the company. High quality people made available to project. High level of SU experience at project initiation. SU manager assigned 100% at Conceptual Engineering Phase. O&M forces reported directly to SU mgr. during SU.	No	0.92	85.1
P-06	Petro. refining	Crude oil pumping and degassing	Mature	Project, including SU, controlled by a Readiness Review Board comprised of government (Owner) and contractor representatives. The board signs off on SU. Contractor acted as engineer, constructor, SU services and operator. Financial success of project to determined after sale of processing equipment	Yes. Project for Federal Government	0.81	54.7

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-08	Chemical	Synthetic Organic Chemical plant.	New	A "race-to-market" project. Sr. Mgmt committed to beat competition. Integrated Project team driven by goal of Plant Commissioning. SU mgr. on project 1st day. Successful SU because it was planned from the beginning	No	0.74	90.6
P-09	Power	Co-gen. power project. Fuel supplied by recovered tailings from coal mine	New	SU services performed by constructor. Sr. mgmt. committed to making SU successful. Successful SU because: • Good quality construction. • CM allowed SU system people to get unit up.	No	0.76	70.5

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-10	Chemical	Synthetic organic chemical intermediate.	Mature	Project was an upgrade at an existing facility of a well-developed process. Sr. mgmt. made project team aware of market pressure to get product out. SU mgr. assigned ~ 100% at conceptual engineering phase. Construction was ahead of schedule, which allowed SU to begin 6-wks earlier than planned. SU team had additional time to prepare for SU. Operations group was well trained and available. In-spec product produced first day of SU	No	0.91	64.9

Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-11	Building	Construction of the mechanical portion of a domed municipal sports complex.	Mature	Met schedule requirements to get systems up for first scheduled pro. football game. SU complex due to lack of coordination with multiple contractors on-site. SU not fully integrated into the master schedule. Owner did not fully anticipate training needs which resulted in inadequate training for operators. Same PM provided good continuity during all phase of the construction.	Yes. The Owner is a quasi-governmental sports authority.	0.60	79.2
P-12	Food	Personal products production facility.	New	Engineer/CM responsible for SU. Design and construction quality excellent allowing for a smooth SU. Good SU plan. Involvement of Owner personnel early on. Design Mgr. became SU Mgr., which was very effective. Got product to market 2-months before planned	No	0.81	76.3

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-13	Food	Breakfast Cereal.	Mature	Owner desired to introduce new product to match competitors product.	Yes. Facility required rabbinical certification of conformance with food handling rules.	0.59	62
P-14	Metal Finishing	Upgrade of an existing steel mill.	Mature	The Owner's most successful SU. Key team members constant from Project Conception to Commercial Operations Extremely detailed SU planning effort which included: • Set up mock DCS system to run simulations of control algorithms. • Extensive training of ops staff. • Constructor performed dry runs to simulate equipment installation. Production capacity above design. Set world record for hot steel making	No	0.85	91.5

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-15	Metal Finishing	Continuous double sided galvanizing of steel.	New	The project was risky. It was a complex, first-of-its-kind, highly automated process for galvanizing of steel. Mgmt/Owner did not provide adequate resources, operators, or mock-up equipment for training which resulted in: ✓ Lack of trained operators at end of SU ✓ Inability to meet production quantity goals ✓ Unable to meet schedule goals. PM had early on team building with Sr. Mgmt of major suppliers to get commitment.	No	0.43	51.2

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-16	Petro. refining	Upgrade of production capacity at an existing facility.	Mature	• Early and significant integration of operations/maintenance group into project planning. • Continuity of key project personnel throughout entire project. SU manager assigned 100% at beginning of Construction Phase. • Extensive operator training program. SU duration reduced from planned 12 weeks to 4 weeks. Good engineering design which facilitated SU Good risk assessment. Feed stock availability a problem	No	0.91	85.7

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-17	Chemical	First massive ethylene plant built. Complex financing increased pressure for successful SU.	Mature	Process somewhat risky because of the large scale-up factor used from older designs Sr. mgmt makes project team aware of severe financial losses if SU not successful. Project financing was complex. SU mgr. assigned (part-time) to project at project authorization and prepared initial SU schedule. SU mgr. Fulltime at beginning of commissioning. SU teams are organized around systems. Execution plans and schedules are very thorough which allow good checkout of all systems. SU duration reduced from 2-weeks to 1-week and plant ran at 105% of design capacity within 30 days after SU. Project significantly over-budget but because plant came on-line when market demand very high, plant was a moneymaker w/in first yr.	No	1.00	89

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-18	Pharmaceutical	A regulatory driven project. Destruction of medical wastes.	New	Project to be delivered by vendor on a turnkey approach. Poor design resulted in failure of the first SU. Required reengineering and rework of feed systems. Project delayed approximately 1-yr. Continuity team was not maintained because of the extended duration of the project. SU manager assigned at end of construction phase. Part-time only. Met quality requirements but at a substantial higher production cost	Yes. Environmental project required for plant.	0.36	37.8

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-19	Pharmaceutical	An R&D facility for product development by scientists. Project was to deliver building and all lab systems required to support research production equipment	New	Good SU planning and organization SU duration as planned. SU success dependent on perspective of user. From project team the facility is a success: From the user the facility did not meet their requirements for sterilization of systems. Project team and end-user needed a clearer understanding of objectives and SU goals.	No	0.86	65.8
P-20	Chemical	Organic chemical intermediate. A complex project that was expected to be difficult. High Sr. mgmt support for SU planning.	Mature	A difficult SU was anticipated which created a highly motivated team. A successful SU. Plant came in on-line w/in-spec product. Business plan met.	No	0.86	87.8
P-21	Chemical	HDPE Plant was one unit in a project involving concurrent construction of other chemical production units.	New	In adequate risk assessment resulting in explosion in off-gas incinerator.	Yes. Incinerator required for operating permit. After explosion air permit problems delayed project 4-6 months	0.38	80

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-22	Manufacturing	Semi-conductor mfg. plant. Strong market and management pressure to get plant on-line.	New	Sr. Mgmt identified this as a priority project. There was good continuity of project team through out project Project over budget due to significant redundancy. Project size made it difficult to track the completion of construction SU successful and majority of systems met performance objectives. Plant production ramps up ahead of schedule resulting in millions of $ in unplanned revenue. Project is extremely profitable	No	0.74	70.7

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-23	Chemical	Organic chemical production.	New	Well planned SU. Plant running at nameplate capacity. Project met business plan. Operations Team performed the SU resulting in a well-trained team at the onset of commercial operations. SU mgr. became plant technical manager. SU mgr. did go through formal SU training. This was a very successful strategy. Good construction/commissioning overlap believed to save 2-months on the schedule. Constructor/SU coordination problems initially occurred because turn--over work was not clearly defined in the lump sum contract. Contract modified which resulted in timesaving for owner.	No	0.80	78

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-24	Chemical	Organic chemical	New	Operations team made an early and significant commitment to the project resulting in highly trained operators at the end of SU. Lead process engineer became the SU mgr. and therefore very knowledgeable about the process. Did go through formal SU training. Constructor did a good job of completing systems for SU. SU duration was earlier than planned. Project is meeting business plan.	No	0.82	79.3

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-25	Chemical	Organic Chemical	New	Good continuity of the project team including the chemist who developed the process. SU successful due to: • Good design and a forgiving process that is easy to operate. • Good SU planning • Good operator training. SU duration was longer than planned due to fed-stock shortages and lack of market demand for finished product. Project met production cost goals.	No	0.75	74.4
P-26	Pharmaceutical	Medicine	New	Good integration of design team into SU team. Actual SU duration longer than planned due to insufficient feedstock and a change in product spec.	No	0.66	50

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-27	Pharmaceutical	Medicine	New	A very successful SU. Operations group had a very detail understanding of the process chemistry. ✓ Operators worked w/ product development team to fully understand the process. Significant Operation/Maint. training: ✓ Mock up of process used from training. ✓ Key operators assign to automation group during I&C design ✓ Separate maint. Group dedicated to SU. ✓ Extensive practice runs. SU manager assigned 100% to project at beginning of detail design	No	0.91	97.6

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-28	Pharmaceutical		Mature	During initial SU production quantity goals not met so rework required. Project is a scale up from proven technology but new equipment did not performed as planned. Experienced SU team. Very early involvement of operations group. Operations group identified the SU systems. Operations team selected their team members.	No	0.65	53.7

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-29	Pulp/paper	Major upgrade of existing plant. Construction was during a period of extremely poor labor relations in the area.	New	A corporate merger caused significant changes in company Sr. Mgmt. The project was an upgraded of the facility acquired in the merger. Unrealistic estimate of SU duration and complexity. The duration was set by mfg. group based on an outage schedule that allowed the plant to meet market demands. Strong market demand for product dictated the time allowed for outages and SU. PM constant through project but project had four engineering managers. Turbine failure in new power unit delayed SU of other units. Expansion of bleach plant unit (the new technology portion) went very poorly which delayed the entire line. SU of upstream process units went smoothly. Project very profitable. Payback period approx. 1/2 the time planned due to high pulp demand and prices.	YES. Serious problems with organized labor. Entire project affected.	0.31	75.3

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Appendix C.1: Summary Comments of Sample Project Characteristics and Outcomes

Project ID	Industry Type	Project Description and Setting	Process Technology	Interviewee Comments re: Project Execution And SU	Externality Present?	SU Success Index	SuPER Score
P-30	Chemical	Project was part of a capacity upgrade and scheduled maintenance project at an existing facility. A demonstration project in which the CII SU model was used as the implementation tool for SU planning.	Mature	The SU was successful but duration was longer than originally planned. The primary reason for the delay was not enough owner forces for SU. SU duration (i.e. downtime for the existing unit) was set by business group and was based on ability to meet customer demand. SU mgr. came from the existing operations group. This was his first experience as SU mgr.	No.	0.79	57

C.2 ACTIVITY PLANNING EFFORT DATA

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Planning Effort Data

Note: Blank = no data / 0 =no effort as activity not done

	Effort Data by Planning Activity														
ProjectID	A1_SR MA	A2_REALI	A3_ESTIM	A4_IMPAC	A5_SU OB	A6_STRAT	A7_TEAM	A8_IDENT	A9_BUDG	A10_O&M	A11_RISK	A12_PROC	A13_INCE	A14_TEAM	A15_SU IN	A17_PLAN
P-03	4		3	5	4	4	4	5		4	5	3	2	4	4	3
P-04	5	5	5	2	4	5	5	5		5	0		4	4	5	5
P-06	4	4	1	0	5	4	4	4		4	2		0	1	0	4
P-08	5	5	4	4	5	5	5	5	3	4	4	3	3	3	5	3
P-09	5	2	1	0	5	5	5	5		0	5		0	5	5	5
P-10	4	3	3	2	5	4	4	4		4	2		0	3	3	3
P-11	5	5	5	0	0	5	5	5		5	1		0	5	5	5
P-12	5	4	4	3	3	5	5	5		3	3	4	0	5	5	4
P-13	1	5	3	0	4	5	5	5		5	3		0	1	0	5
P-14	5	5	0	5	5	5	5	4	4	5	5	5	0	5	5	5
P-15	4	2	2	5	3	4	4	2	4	2	5	4	0	2	2	3
P-16	3	5	5	5	5	5	4	5		5	4		5	5	4	5
P-17	5	3	4	5	4	4	3	4	3	5	5	5	0	5	4	4
P-18	0	2	0	0	0	3	5	4	0	5	0	3	0	0	2	5
P-19	1	4	3	2	3	5	5	5	5	5	4	3	0	0	5	3
P-20	4	4	0	4	4	5	5	5	3	5	5	5	3	5	4	4
P-21	4	4	0	4	4	5	5	5	3	5	2	5	3	5	4	4
P-22	5	4	0	1	5	5	4	5	4	2	5	5	0	1	5	2
P-23	4	3	3	3	5	5	4	5	4	4	4	3	3	2	4	4
P-24	4	3	3	5	5	4	5	5	1	5	4	2	0	0	5	0
P-25	4	4	4	4	4	5	3	0	4	5	5	3	0	4	3	4
P-26	4	2	4	3	3	4	2	4	5	2	2	4	1	2	3	2
P-27	5	5	5	5	5	5	5	5	3	5	5	4	2	5	5	5
P-28	0	4	1	0	3	4	4	4	1	5	1	3	4	4	2	2
P-29	5	0	5	5	5	5	5	5	5	5	3	5	0	5	5	5
P-30	1	1	3	3	1	3	1	5	3	1	3	5	3	5	5	5

Planning Effort Data

Effort Data by Planning Activity												
A18_PRE-	A19_SU S	A20_OPE	A21_SPA	A22_PRIO	A23_ASS	A24_PRO	A25_SYS	A27_TRA	A28_CON	A29_OPE	A32_PER	ProjectID
4	4	5	4		5	5	4	4	4	4	2	P-03
5	3	5	5		4	5	5	5	3	5	5	P-04
3	0	4	4		2	5	5	0	0	4	4	P-06
3	5	5	3	5	4	5	5	5	4	4	5	P-08
0	0	5	0		5	5	5	5	5	5	5	P-09
2	4	3	4		4	4	4	3	3	5	4	P-10
3	0	5	3		5	3	5	4	5	5	5	P-11
	0	4	3		5	5	5	5	5	3	4	P-12
5	4	2	3		5	5	0	4	1			P-13
5	2	5	5	5	5	5	5	3	3	5	5	P-14
4	2	2	4	3	5	3	5	4	2	2	0	P-15
4	3	5	5		5	5	4	3	4	5	5	P-16
4	5	5	4	4	3	5	5	5	1	5	3	P-17
1	5	4	5	0	4	3	2	5	1	3	0	P-18
3	0	3	5	5	0	0	5	5	0	4	3	P-19
3	0	5	5	5	4	5	5	5	4	5	3	P-20
3	0	5	5	5	4	2	5	5	4	5	3	P-21
3	3	2	0	5	4	5	5	5	3	2	2	P-22
3	4	3	4	3	4	5	5	5	3	5	3	P-23
4	5	3	1	2	4	5	5	5	0	5	5	P-24
3	0	5	4	5	3	5	4	3	4	5	4	P-25
4	5	4	3	4	4	2	3	3	1	3	2	P-26
5	5	5	5	5	4	5	5	4	3	5		P-27
3	2	4	2	3	1	4	4	5	2	4	0	P-28
5	5	1	5	3	2	5	5	5	5	1	5	P-29
0	0	5	5	1	3	5	5	5	5	5	5	P-30

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C.3 ACTIVITY TIMING DATA

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Planning Phase Data

Note: Blanks indicate no data or activity not done.

ProjectID	Phase Data by Planning Activity															
	A1_SR M/	A2_REALI	A3_ESTIM	A4_IMPAC	A5_SU OI	A6_STRA	A7_TEAM	A8_IDENT	A9_BUDG	A10_O&M	A11_RISK	A12_PRO	A13_INCE	A14_TEAI	A15_SU II	A17_PLAI
P-03	4	3	2	2	5	5	5	6		3	3	6	7	5	6	6
P-04	2	2	2	1	2	2	2	3		2			3	3	2	2
P-06	2	4	3		2	4	4	4		4	2			5		4
P-08	2	2	2	3	2	2	3	3	5	3	3	5	5	6	4	6
P-09	5	5	4		5	5	5	5			2			5	5	5
P-10	2	3	2	8	2	3	3	3		3	2			3	5	4
P-11	5	5	5			5	5	5		6	5			2	5	4
P-12	4	4	4	4	4	4	4	4		6				5	4	4
P-13	5	5	2		5	5	5	5		4	5			5		4
p-14	1	1		1	1	2	2	3	3	1	1	2		2	3	3
P-15	2	2	2	2	2	5	5	4	3	5	5	5		4	4	4
P-16	4	3	3	3	3	4	5	4		2	4		2	2	5	3
P-17	3	1	1	1	3	4	4	3	2	2	1	4		4	2	4
P-18		3				6	6	3		7		4			2	6
P-19	6	2	2	2	6	5	5	5	5	5	5	5				2
P-20	3	4		5	3	3	4	5	5	2	2	3	5	5	5	4
P-21	3	4		5	3	3	4	5	5	2	5	3	5	5	5	4
P-22	1	5		1	4	4	4	4	5	4	4	2		5	2	5
P-23	3	4	4	3	3	4	1	5	5	3	3	5	4	5	3	4
P-24	3	4	4	3	4	5	3	4	5	3	6	6		0	3	6
P-25	4	4	3	3	4	4	4		5	3	3	4		5	4	4
P-26	3	2	2	6	4	2	5	2	4	5	5	3	6	4	2	4
P-27	1	3	3	3	4	4	4	4	5	1	1	4	5	2	4	4
P-28		4	4		4	4	4	4	6	4	5	5	5	4	4	5
P-29	3	3	3	3	3	3	5	5	5	3	5	4		3	3	4
P-30	4	4	2	2	4	4	4	3	5	4	4	4	4	4	4	4

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Planning Phase Data

Phase Data by Planning Activity												
A18_PRE	A19_SU S	A20_OPE	A21_SPA	A22_PRIC	A23_ASS	A24_PRO	A25_SYS	A27_TRA	A28_CON	A29_OPE	A32_PER	ProjectID
4	4	5	4		5	3	5	5	5	5	6	P-03
2	5	4	3		5	3	3	5	5	5	8	P-04
4		4	4		5	4	4			5	6	P-06
5	4	4	5	3	4	4	3	5	5	5	6	P-08
		5			6	5	5	5	5	5	7	P-09
4	4	5	3		3	3	3	5	5	5	8	P-10
4		4	4		2	4	5	5	6	6	8	P-11
4		4	4		3	4	4	5	5	7	8	P-12
4	4	5	3		4	5			5	6		P-13
3		3	3	3	3	3	3	4	5	5	8	p-14
4	5	4	4	5	5	5	4	5	5	4		P-15
3	4	3	4		4	3	5		5	5	8	P-16
3	2	3	4	3	3	3	3	4	5	4	8	P-17
4	3	6	4		6	6	5	7	7	5		P-18
2		5	2	5			5	4		5		P-19
5		5	2	5	5	5	5	5	5	5	8	P-20
5		5	2	5	5	5	5	5	5	5	8	P-21
4	4	5		3	5	3	4	4	5	4	7	P-22
4	5	4	4	6	4	4	5	5	4	5	8	P-23
4	4	4	4	4	5	5	4	4		5	7	P-24
4		4	4	5	5	3	4	5	4	5	8	P-25
4	4	5	5	6	4	7	5	5	6	7	8	P-26
2	3	5	5	4	5	4	5	5	5	5		P-27
4	5	5	5	5	5	4	5	6	5	5		P-28
3	5	3	3	5	5	4	5	5	5	4	8	P-29
3	3	4	4	4	4	4	3	5	5	7	8	P-30

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Appendix D   Multiple Regression Results

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D.1 REGRESSION ANALYSIS DATA SET

PROJECT	TYPE	SU_INX	SUPER	YEARS	TIC_M$	LOG_TIC	PROCESS	TECH	CONSTRUC	SITE	REGUL	REG
P-03	Chemical	34.12	79	25	130.0	8.11	New	0	Grass roots	0	Yes	1
P-04	Power	92.00	85	22	1200.0	9.08	Mature	1	Grass roots	0	No	0
P-06	Petro. re	80.71	55	18	43.0	7.63	Mature	1	Grass roots	0	Yes	1
P-08	Chemical	73.94	91	24	150.0	8.18	New	0	Grass roots	0	No	0
P-09	Power	76.00	71	22	70.0	7.85	New	0	Grass roots	0	No	0
P-10	Chemical	91.18	65	21	13.0	7.11	Mature	1	Retrofit	1	No	0
P-11	Building	60.00	79	23	42.0	7.62	Mature	1	Grass roots	0	Yes	1
P-12	Food	81.33	76	10	30.0	7.48	New	0	Grass roots	0	No	0
P-13	Food	59.35	62	30	7.0	6.85	Mature	1	Retrofit	1	Yes	1
P-14	Metals	85.29	92	28	80.0	7.90	Mature	1	Retrofit	1	No	0
P-15	Metals	43.45	51	40	200.0	8.30	New	0	Grass roots	0	No	0
P-16	Petro. re	90.81	86	17	250.0	8.40	Mature	1	Retrofit	1	No	0
P-17	Chemical	100.00	89	26	550.0	8.74	Mature	1	Grass roots	0	No	0
P-18	Pharm.	35.68	38	30	17.0	7.23	New	0	Grass roots	0	Yes	1
P-19	Pharm	86.25	66	18	30.0	7.48	New	0	Retrofit	1	No	0
P-20	Chemical	85.81	88	30	490.0	8.69	Mature	1	Grass roots	0	No	0

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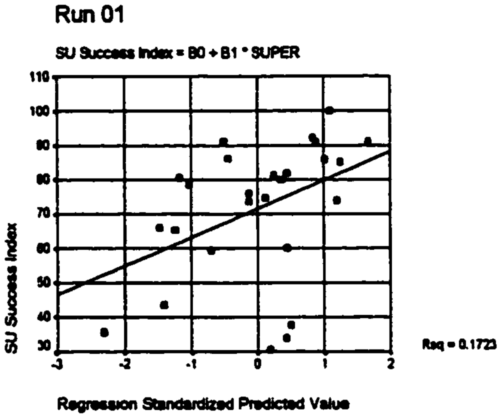
D.1 Regression Analysis Data Set (cont'd)

PROJECT	TYPE	SU_INX	SUPER	YEARS	TIC_M$	LOG_TIC	PROCESS	TECH	CONSTRUC	SITE	REGUL	REG
P-21	Chemical	37.71	80	13	115.0	8.06	New	0	Grass roots	0	Yes	1
P-22	Mfgr.	73.53	71	9	1500.0	9.18	New	0	Grass roots	0	No	0
P-23	Chemical	80.00	78	30	50.0	7.70	New	0	Grass roots	0	No	0
P-24	Chemical	82.00	79	17	57.0	7.76	New	0	Grass roots	0	No	0
P-25	Chemical	74.67	74	16	13.5	7.13	New	0	Retrofit	1	No	0
P-26	Pharm	66.11	50	13	88.0	7.94	New	0	Grass roots	0	No	0
P-27	Pharm	91.20	98	14	160.0	8.20	New	0	Retrofit	1	No	0
P-28	Pharm	65.33	54	12	6.3	6.80	Mature	1	Retrofit	1	No	0
P-29	Pulp/pap	30.59	75	35	425.0	8.63	New	0	Retrofit	1	Yes	1
P-30	Chemical	78.67	57	16	12.5	7.10	Mature	1	Retrofit	1	No	0

D.2 REGRESSION MODEL DETAIL RESULTS (RUNS 01 – 08)

Regression Run 01

Charts



Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.415[a]	.172	.138	18.6429

[a] Predictors: (Constant), SuPER Tool Score

[b] Dependent Variable: SU Success Index

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	31.302	18.294		1.711	.100
	SuPER Tool Score	.552	.247	.415	2.236	.035

[a] Dependent Variable: SU Success Index

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ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1736.974	1	1736.974	4.998	.035[a]
	Residual	8341.388	24	347.558		
	Total	10078.362	25			

a. Predictors: (Constant), SuPER Tool Score

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26

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Correlations

		SU Success Index	SuPER Tool Score
Pearson Correlation	SU Success Index	1.000	.415
	SuPER Tool Score	.415	1.000
Sig. (1-tailed)	SU Success Index	.	.017
	SuPER Tool Score	.017	.
N	SU Success Index	26	26
	SuPER Tool Score	26	26

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	52.1715	85.1876	71.3743	8.3354	26
Residual	-42.2873	24.0428	2.733E-15	18.2662	26
Std. Predicted Value	-2.304	1.657	.000	1.000	26
Std. Residual	-2.268	1.290	.000	.980	26

a. Dependent Variable: SU Success Index

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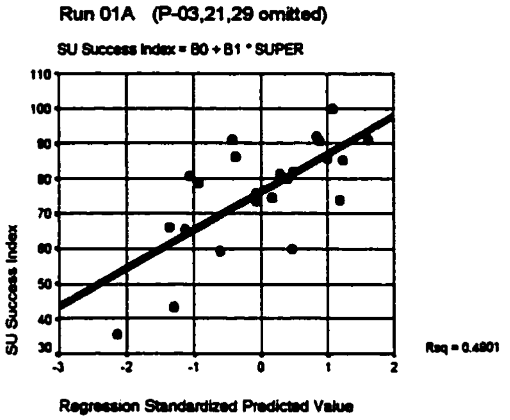
Regression Run 01A
Charts



Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.700[a]	.490	.466	11.3994

a. Predictors: (Constant), SuPER Tool Score

b. Dependent Variable: SU Success Index

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2622.460	1	2622.460	20.181	.000[a]
	Residual	2728.851	21	129.945		
	Total	5351.312	22			

a. Predictors: (Constant), SuPER Tool Score

b. Dependent Variable: SU Success Index

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Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	26.979	11.218		2.405	.025
	SuPER Tool Score	.685	.153	.700	4.492	.000

a. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	76.2309	15.5962	23
SuPER Tool Score	71.8609	15.9298	23

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Correlations

		SU Success Index	SuPER Tool Score
Pearson Correlation	SU Success Index	1.000	.700
	SuPER Tool Score	.700	1.000
Sig. (1-tailed)	SU Success Index	.	.000
	SuPER Tool Score	.000	.
N	SU Success Index	23	23
	SuPER Tool Score	23	23

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	52.8862	93.8720	76.2309	10.9180	23
Residual	-21.2610	19.7164	-8.6501E-15	11.1373	23
Std. Predicted Value	-2.138	1.616	.000	1.000	23
Std. Residual	-1.865	1.730	.000	.977	23

a. Dependent Variable: SU Success Index

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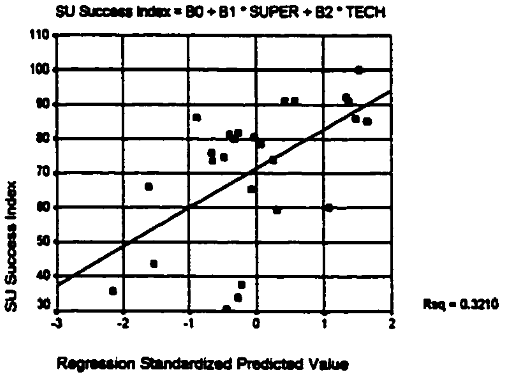
Regression Run 02

Charts

Run 02



Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.567[a]	.321	.262	17.2494

a. Predictors: (Constant), TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

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Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	27.183	17.026		1.597	.124
	SuPER Tool Score	.519	.229	.390	2.267	.033
	TECH CODE	15.395	6.861	.386	2.244	.035

a. Dependent Variable: SU Success Index

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3234.902	2	1617.451	5.436	.012[a]
	Residual	6843.460	23	297.542		
	Total	10078.362	25			

a. Predictors: (Constant), TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26
TECH CODE	.4231	.5038	26

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Correlations

		SU Success Index	SuPER Tool Score	TECH CODE
Pearson Correlation	SU Success Index	1.000	.415	.411
	SuPER Tool Score	.415	1.000	.064
	TECH CODE	.411	.064	1.000
Sig. (1-tailed)	SU Success Index	.	.017	.018
	SuPER Tool Score	.017	.	.378
	TECH CODE	.018	.378	.
N	SU Success Index	26	26	26
	SuPER Tool Score	26	26	26
	TECH CODE	26	26	26

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	46.8056	90.0775	71.3743	11.3752	26
Residual	-35.6842	24.9091	5.192E-15	16.5450	26
Std. Predicted Value	-2.160	1.644	.000	1.000	26
Std. Residual	-2.069	1.444	.000	.959	26

a. Dependent Variable: SU Success Index

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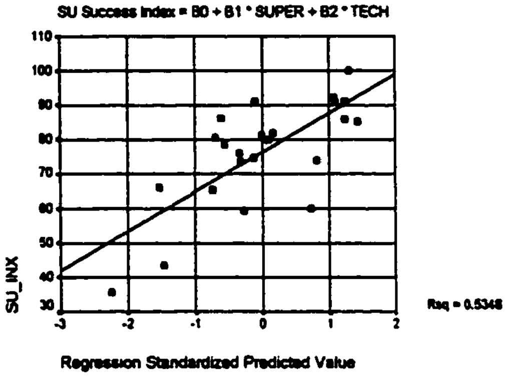
Regression Run 02A

Charts

Run 02_A No Outliers (P-03,-21,-29)



Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.731^a	.535	.488	11.1571

a. Predictors: (Constant), TECH_COD, SUPER

b. Dependent Variable: SU_INX

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	25.555	11.028		2.317	.031
	SUPER	.662	.150	.676	4.405	.000
	TECH_COD	6.498	4.687	.213	1.386	.181

a. Dependent Variable: SU_INX

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ANOVA^{a,b}

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2861.708	2	1430.854	11.495	.00
	Residual	2489.603	20	124.480		
	Total	5351.312	22			

a. Predictors: (Constant), TECH_COD, SUPER

b. Dependent Variable: SU_INX

Descriptive Statistics

	Mean	Std. Deviation	N
SU_INX	76.2309	15.5962	23
SUPER	71.8609	15.9298	23
TECH_COD	.48	.51	23

Correlations

		SU_INX	SUPER	TECH_COD
Pearson Correlation	SU_INX	1.000	.700	.289
	SUPER	.700	1.000	.112
	TECH_COD	.289	.112	1.000
Sig. (1-tailed)	SU_INX	.	.000	.091
	SUPER	.000	.	.305
	TECH_COD	.091	.305	.
N	SU_INX	23	23	23
	SUPER	23	23	23
	TECH_COD	23	23	23

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Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	50.5766	92.6212	76.2309	11.4052	23
Residual	-24.4792	17.1387	4.325E-15	10.6378	23
Std. Predicted Value	-2.249	1.437	.000	1.000	23
Std. Residual	-2.194	1.536	.000	.953	23

a. Dependent Variable: SU_INX

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	50.5766	92.6212	76.2309	11.4052	23
Residual	-24.4792	17.1387	4.325E-15	10.6378	23
Std. Predicted Value	-2.249	1.437	.000	1.000	23
Std. Residual	-2.194	1.536	.000	.953	23

a. Dependent Variable: SU_INX

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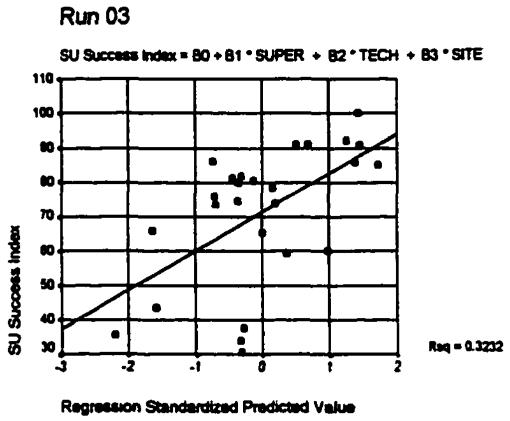
Regression Run 03

Charts



Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.569[a]	.323	.231	17.6081

a. Predictors: (Constant), CONSTRUCTION CODE, SuPER Tool Score, TECH CODE

b. Dependent Variable: SU Success Index

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	26.619	17.506		1.521	.143
	SuPER Tool Score	.520	.234	.391	2.223	.037
	TECH CODE	14.839	7.303	.372	2.032	.054
	CONSTRUCTION CODE	1.992	7.401	.049	.269	.790

a. Dependent Variable: SU Success Index

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ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3257.359	3	1085.786	3.502	.032[a]
	Residual	6821.003	22	310.046		
	Total	10078.362	25			

a. Predictors: (Constant), CONSTRUCTION CODE, SuPER Tool Score, TECH CODE

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26
TECH CODE	.4231	.5038	26
CONSTRUCTION CODE	.3846	.4961	26

Correlations

		SU Success Index	SuPER Tool Score	TECH CODE	CONSTRUCTIO CODE
Pearson Correlation	SU Success Index	1.000	.415	.411	.15
	SuPER Tool Score	.415	1.000	.064	.01
	TECH CODE	.411	.064	1.000	.28
	CONSTRUCTION CODE	.159	.011	.283	1.00
Sig. (1-tailed)	SU Success Index	.	.017	.018	.21
	SuPER Tool Score	.017	.	.378	.47
	TECH CODE	.018	.378	.	.08
	CONSTRUCTION CODE	.219	.478	.081	
N	SU Success Index	26	26	26	2
	SuPER Tool Score	26	26	26	2
	TECH CODE	26	26	26	2
	CONSTRUCTION CODE	26	26	26	2

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Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	46.2588	90.9911	71.3743	11.4147	26
Residual	-37.1466	23.4512	2.733E-16	16.5179	26
Std. Predicted Value	-2.200	1.719	.000	1.000	26
Std. Residual	-2.110	1.332	.000	.938	26

a. Dependent Variable: SU Success Index

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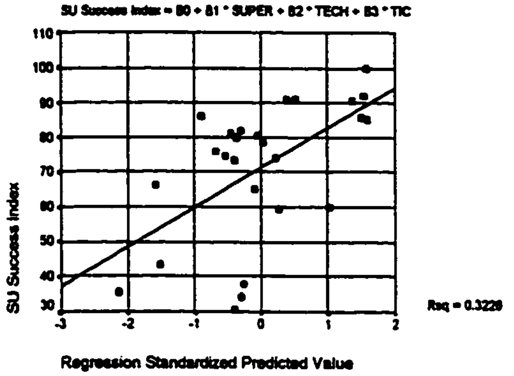
Regression: Run 04

Charts



Run 04

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.568[a]	.323	.230	17.6153

a. Predictors: (Constant), TIC, TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	27.744	17.553		1.581	.128	-8.659	64.14
	SuPER Tool Score	.505	.242	.380	2.087	.049	.003	1.00
	TECH CODE	15.324	7.014	.385	2.185	.040	.779	29.87
	TIC	2.320E-09	.000	.042	.233	.818	.000	.00

a. Dependent Variable: SU Success Index

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ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3251.767	3	1083.922	3.493	.033^a
	Residual	6826.595	22	310.300		
	Total	10078.362	25			

a. Predictors: (Constant), TIC, TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26
TECH CODE	.4231	.5038	26
TIC	$220,357,692.3077	$366,744,917.5360	26

Correlations

		SU Success Index	SuPER Tool Score	TECH CODE	TIC
Pearson Correlation	SU Success Index	1.000	.415	.411	.16
	SuPER Tool Score	.415	1.000	.064	.25
	TECH CODE	.411	.064	1.000	.05
	TIC	.163	.257	.058	1.00
Sig. (1-tailed)	SU Success Index	.	.017	.018	.21
	SuPER Tool Score	.017	.	.378	.10
	TECH CODE	.018	.378	.	.38
	TIC	.214	.102	.388	
N	SU Success Index	26	26	26	2
	SuPER Tool Score	26	26	26	2
	TECH CODE	26	26	26	2
	TIC	26	26	26	2

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Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	46.8632	89.4392	71.3743	11.4049	26
Residual	-36.1500	25.2233	4.646E-15	16.5246	26
Std. Predicted Value	-2.149	1.584	.000	1.000	26
Std. Residual	-2.052	1.432	.000	.938	26

a. Dependent Variable: SU Success Index

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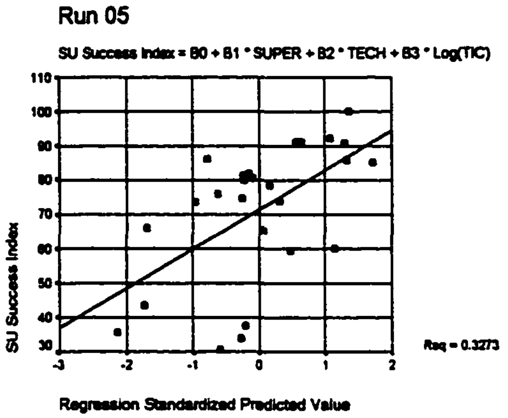
Regression: Run 05

Charts



Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.572[a]	.327	.236	17.5545

a. Predictors: (Constant), LOG_TIC, TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients			95% Confidence Interval for B	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1	(Constant)	45.411	43.604		1.041	.309	-45.017	135.84
	SuPER Tool Score	.585	.274	.440	2.136	.044	.017	1.15
	TECH CODE	14.875	7.076	.373	2.102	.047	.201	29.54
	LOG_TIC	-2.884	6.330	-.094	-.456	.653	-16.012	10.24

a. Dependent Variable: SU Success Index

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ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3298.856	3	1099.619	3.568	.031
	Residual	6779.505	22	308.159		
	Total	10078.362	25			

a. Predictors: (Constant), LOG_TIC, TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26
TECH CODE	.4231	.5038	26
LOG_TIC	7.8901	.6550	26

Correlations

		SU Success Index	SuPER Tool Score	TECH CODE	LOG_TIC
Pearson Correlation	SU Success Index	1.000	.415	.411	.09
	SuPER Tool Score	.415	1.000	.064	.51
	TECH CODE	.411	.064	1.000	-.10
	LOG_TIC	.092	.514	-.105	1.00
Sig. (1-tailed)	SU Success Index	.	.017	.018	.32
	SuPER Tool Score	.017	.	.378	.00
	TECH CODE	.018	.378	.	.30
	LOG_TIC	.327	.004	.304	
N	SU Success Index	26	26	26	2
	SuPER Tool Score	26	26	26	2
	TECH CODE	26	26	26	2
	LOG_TIC	26	26	26	2

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Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	46.6539	90.9768	71.3743	11.4871	26
Residual	-34.0699	23.9413	6.286E-15	16.4676	26
Std. Predicted Value	-2.152	1.706	.000	1.000	26
Std. Residual	-1.941	1.364	.000	.938	26

[a] Dependent Variable: SU Success Index

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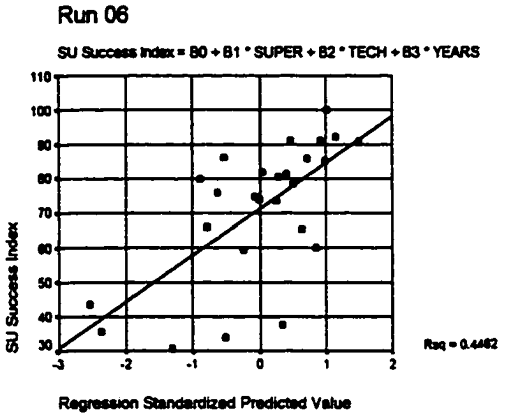
Regression: Run 06

Charts



Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.668[a]	.446	.371	15.9273

a. Predictors: (Constant), Industry Experience, SuPER Tool Score, TECH CODE

b. Dependent Variable: SU Success Index

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	47.333	18.131		2.611	.016
	SuPER Tool Score	.500	.212	.376	2.361	.027
	TECH CODE	16.345	6.350	.410	2.574	.017
	Industry Experience	-.890	.399	-.355	-2.231	.036

a. Dependent Variable: SU Success Index

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ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4497.415	3	1499.138	5.910	.004[a]
	Residual	5580.947	22	253.679		
	Total	10078.362	25			

a. Predictors: (Constant), Industry Experience, SuPER Tool Score, TECH CODE

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26
TECH CODE	.4231	.5038	26
Industry Experience	21.5000	8.0062	26

Correlations

		SU Success Index	SuPER Tool Score	TECH CODE	Industry Experience
Pearson Correlation	SU Success Index	1.000	.415	.411	-.34
	SuPER Tool Score	.415	1.000	.064	-.03
	TECH CODE	.411	.064	1.000	.06
	Industry Experience	-.342	-.037	.064	1.00
Sig. (1-tailed)	SU Success Index	.	.017	.018	.04
	SuPER Tool Score	.017	.	.378	.42
	TECH CODE	.018	.378	.	.37
	Industry Experience	.043	.429	.377	
N	SU Success Index	26	26	26	2
	SuPER Tool Score	26	26	26	2
	TECH CODE	26	26	26	2
	Industry Experience	26	26	26	2

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Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	37.3074	91.3648	71.3743	13.4126	26
Residual	-38.0188	22.0630	1.776E-15	14.9411	26
Std. Predicted Value	-2.540	1.490	.000	1.000	26
Std. Residual	-2.387	1.385	.000	.938	26

a. Dependent Variable: SU Success Index

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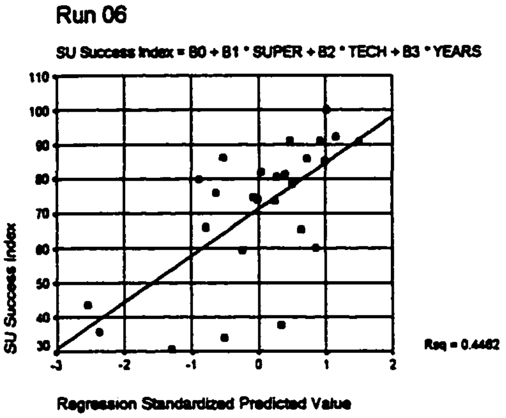
Regression: Run 06

Charts



Run 06

SU Success Index = B0 + B1 * SUPER + B2 * TECH + B3 * YEARS

Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.668[a]	.446	.371	15.9273

a. Predictors: (Constant), Industry Experience, SuPER Tool Score, TECH CODE

b. Dependent Variable: SU Success Index

Coefficients [a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	47.333	18.131		2.611	.016
	SuPER Tool Score	.500	.212	.376	2.361	.027
	TECH CODE	16.345	6.350	.410	2.574	.017
	Industry Experience	-.890	.399	-.355	-2.231	.036

a. Dependent Variable: SU Success Index

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ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4497.415	3	1499.138	5.910	.004
	Residual	5580.947	22	253.679		
	Total	10078.362	25			

a. Predictors: (Constant), Industry Experience, SuPER Tool Score, TECH CODE

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	71.3743	20.0782	26
SuPER Tool Score	72.5808	15.0974	26
TECH CODE	.4231	.5038	26
Industry Experience	21.5000	8.0062	26

Correlations

		SU Success Index	SuPER Tool Score	TECH CODE	Industry Experience
Pearson Correlation	SU Success Index	1.000	.415	.411	-.34
	SuPER Tool Score	.415	1.000	.064	-.03
	TECH CODE	.411	.064	1.000	.06
	Industry Experience	-.342	-.037	.064	1.00
Sig. (1-tailed)	SU Success Index	.	.017	.018	.04
	SuPER Tool Score	.017	.	.378	.42
	TECH CODE	.018	.378	.	.37
	Industry Experience	.043	.429	.377	
N	SU Success Index	26	26	26	2
	SuPER Tool Score	26	26	26	2
	TECH CODE	26	26	26	2
	Industry Experience	26	26	26	2

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Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	37.3074	91.3648	71.3743	13.4126	26
Residual	-38.0188	22.0630	1.776E-15	14.9411	26
Std. Predicted Value	-2.540	1.490	.000	1.000	26
Std. Residual	-2.387	1.385	.000	.938	26

a. Dependent Variable: SU Success Index

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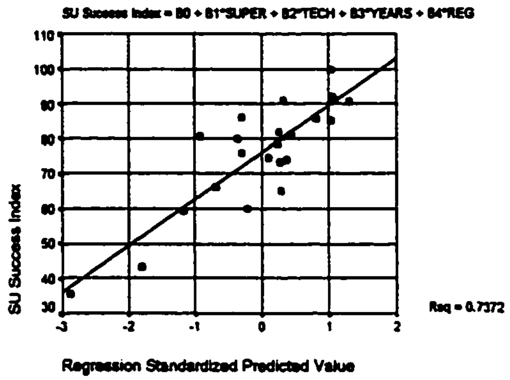
Regression Run 07

Charts

Run 07



Model Summary ^{b}

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.859^a	.737	.679	8.8398

a. Predictors: (Constant), Reg Factor, Industry Experience, TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients			Correlations		
		B	Std. Error	Beta	t	Sig.	Zero-order	Partial	Par
1	(Constant)	49.295	10.838		4.548	.000			
	SuPER Tool Score	.507	.133	.518	3.821	.001	.700	.669	.46
	TECH CODE	10.626	3.928	.348	2.705	.014	.289	.538	.32
	Industry Experience	-.582	.251	-.290	-2.321	.032	-.352	-.480	-.28
	Reg Factor	-13.276	5.742	-.330	-2.312	.033	-.520	-.479	-.27

a. Dependent Variable: SU Success Index

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ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3944.758	4	986.189	12.620	.000^a
	Residual	1406.554	18	78.142		
	Total	5351.312	22			

a. Predictors: (Constant), Reg Factor, Industry Experience, TECH CODE, SuPER Tool Score

b. Dependent Variable: SU Success Index

Descriptive Statistics

	Mean	Std. Deviation	N
SU Success Index	76.2309	15.5962	23
SuPER Tool Score	71.8609	15.9298	23
TECH CODE	.4783	.5108	23
Industry Experience	21.1304	7.7829	23
Reg Factor	.1739	.3876	23

Correlations

		SU Success Index	SuPER Tool Score	TECH CODE	Industry Experience	Reg Factor
Pearson Correlation	SU Success Index	1.000	.700	.289	-.352	-.5
	SuPER Tool Score	.700	1.000	.112	-.042	-.3
	TECH CODE	.289	.112	1.000	.121	.2
	Industry Experience	-.352	-.042	.121	1.000	.2
	Reg Factor	-.520	-.398	.250	.248	1.0
Sig. (1-tailed)	SU Success Index		.000	.091	.050	.0
	SuPER Tool Score	.000		.305	.425	.0
	TECH CODE	.091	.305	.	.291	.1
	Industry Experience	.050	.425	.291		.1
	Reg Factor	.005	.031	.125	.127	
N	SU Success Index	23	23	23	23	[illegible]
	SuPER Tool Score	23	23	23	23	[illegible]
	TECH CODE	23	23	23	23	[illegible]
	Industry Experience	23	23	23	23	[illegible]
	Reg Factor	23	23	23	23	[illegible]

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Residuals Statistics [a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	37.7370	93.5097	76.2309	13.3906	23
Residual	-14.8498	16.7919	-8.6501E-15	7.9859	23
Std. Predicted Value	-2.875	1.290	.000	1.000	23
Std. Residual	-1.680	1.900	.000	.905	23

a. Dependent Variable: SU Success Index

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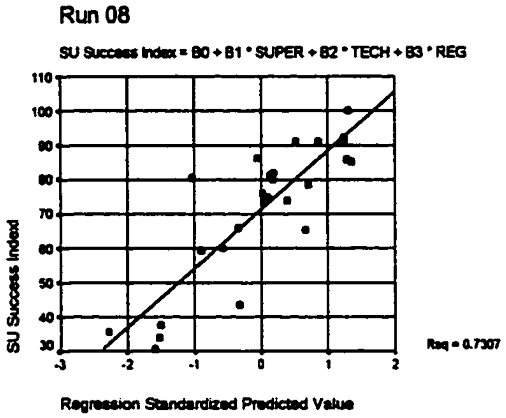
Regression: Run 08

Charts



Model Summary [b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.855[a]	.731	.694	11.1066

a. Predictors: (Constant), REG, TECH_COD, SUPER

b. Dependent Variable: SU_INX

Coefficients [a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	49.821	11.640		4.280	.000			
	SUPER	.312	.152	.235	2.059	.052	.415	.402	.22
	TECH_COD	15.970	4.419	.401	3.614	.002	.411	.610	.40
	REG	-29.237	5.053	-.659	-5.786	.000	-.711	-.777	-.64

a. Dependent Variable: SU_INX

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ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7364.513	3	2454.838	19.900	.000^a
	Residual	2713.849	22	123.357		
	Total	10078.362	25			

a. Predictors: (Constant), REG, TECH_COD, SUPER

b. Dependent Variable: SU_INX

Descriptive Statistics

	Mean	Std. Deviation	N
SU_INX	71.3743	20.0782	26
SUPER	72.5808	15.0974	26
TECH_COD	42	.50	26
REG	.27	45	26

Correlations

		SU_INX	SUPER	TECH_COD	REG
Pearson Correlation	SU_INX	1.000	.415	.411	-.711
	SUPER	415	1.000	.084	-.235
	TECH_COD	411	.084	1.000	007
	REG	-.711	-.235	.007	1.000
Sig. (1-tailed)	SU_INX		.017	018	000
	SUPER	017		378	124
	TECH_COD	018	378	.	487
	REG	000	.124	487	
N	SU_INX	26	26	26	26
	SUPER	26	26	26	26
	TECH_COD	26	26	26	26
	REG	26	26	26	26

Residuals Statistics^a

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	32.3898	94.3681	71.3743	17.1633	26
Residual	-22.3831	27.0780	2.384E-14	10.4189	26
Std. Predicted Value	-2.271	1.340	.000	1.000	26
Std. Residual	-2.013	2.438	.000	.938	26

a. Dependent Variable: SU_INX

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Appendix E Analysis of Startup Success Results

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E.1 PLANNING EFFORT VS. STARTUP SUCCESS CORRELATION

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APPENDIX E.1

Bivariate Analysis:

Planning Effort vs. Startup Success Correlations

	Model Activity	SU_INDX
Pearson Correlation	A1_SR MANAGEMENT COMMITMENT_Exte	.203
	A10_O&M IMPUT_Extent of use	.024
	A11_RISKS_Extent of use	.229
	A12_PROCUREMENT_Extent of use	.040
	A13_INCENTIVES_Extent of use	.136
	A14_TEAM BUILDING_Extent of use	.108
	A15_SU IN PROJ CPM_Extent of use	.243
	A17_PLAN FOR SUPPLIER SUPORT_Ext	-.016
	A18_PRE-SHIPMENT TESTING_Extent	.014
	A19_SU SYSTEM # ON ENG DELIVERAB	-.091
	A2_REALISTIC STARTUP DURATION FO	.432*
	A20_OPERATOR TRAINING PLAN_Exten	.318
	A21_SPARE PARTS PLAN_Extent of u	-.041
	A22_PRIORITIES & SEQUENCE_Extent	.373
	A23_ASSESS & COMMUNICATE EFFECTS	-.088
	A24_PROCEDURES/PROCESS SAFETY MA	.272
	A25_SYSTEM TURMOVER PLAN_Extent	.303

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	Model Activity	SU_INDX
Pearson Correlation	A27_TRANSITION TO SYSTEMS-BASED	-.137
	A28_CONSTRUCTION-SU TEAM BUILDIN	-.135
	A29_OPERATOR TRAINING_Extent of	.573**
	A3_ESTIMATE SU COSTS_Extent	.202
	A32_PERFORMANCE MEASURES & FINAL	.440*
	A4_IMPACT ON ECONOMICS_Extent of	.054
	A5_SU OBJECTIVES_Extent	.335*
	A6_STRATEGY & EXECUTION PLAN_Ext	.199
	A7_TEAM ASSIGMENTS_Extent	-.126
	A8_IDENTIFY SYSTEMS_Extent of us	.074
	A9_BUDGET & SCHEDULE_Extent of u	.085
	SU_INDX	1.000
	SUPER	.415*

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	Model Activity	SU_INDX
Sig. (1-tailed)	A1_SR MANAGEMENT COMMITMENT_Exte	.160
	A10_O&M IMPUT_Extent of use	.453
	A11_RISKS_Extent of use	.131
	A12_PROCUREMENT_Extent of use	.436
	A13_INCENTIVES_Extent of use	.253
	A14_TEAM BUILDING_Extent of use	.300
	A15_SU IN PROJ CPM_Extent of use	.116
	A17_PLAN FOR SUPPLIER SUPORT_Ext	.469
	A18_PRE-SHIPMENT TESTING_Extent	.473
	A19_SU SYSTEM # ON ENG DELIVERAB	.328
	A2_REALISTIC STARTUP DURATION FO	.016
	A20_OPERATOR TRAINING PLAN_Exten	.057
	A21_SPARE PARTS PLAN_Extent of u	.422
	A22_PRIORITIES & SEQUENCE_Extent	.070
	A23_ASSESS & COMMUNICATE EFFECTS	.334
	A24_PROCEDURES/PROCESS SAFETY MA	.089
	A25_SYSTEM TURMOVER PLAN_Extent	.066
	A27_TRANSITION TO SYSTEMS-BASED	.253
	A28_CONSTRUCTION-SU TEAM BUILDIN	.256
	A29_OPERATOR TRAINING_Extent of	.001
	A3_ESTIMATE SU COSTS_Extent	.161

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	Model Activity	SU_INDX
Sig. (1-tailed)	A32_PERFORMANCE MEASURES & FINAL	.016
	A4_IMPACT ON ECONOMICS_Extent of	.397
	A5_SU OBJECTIVES_Extent	.047
	A6_STRATEGY & EXECUTION PLAN_Ext	.165
	A7_TEAM ASSIGMENTS_Extent	.269
	A8_IDENTIFY SYSTEMS_Extent of us	.360
	A9_BUDGET & SCHEDULE_Extent of u	.373
	SU_INDX	.
	SUPER	.018

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E.2 PLANNING PHASE VS. STARTUP SUCCESS CORRELATION

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APPENDIX E.2

Bivariate Analysis:

Planning Phase vs. Startup Success Correlations

Correlations

Statistics	Model Activity	SU_INX
Pearson Correlation	A1_ SR MANAGEMENT COMMITMENT_Pha	-.150
	A10_O&M IMPUT_Phase	-.389*
	A11_RISKS_Phase	-.539**
	A12_PROCUREMENT_Phase	-.141
	A13_INCENTIVES_Phase	-.693**
	A14_TEAM BUILDING_Phase	-.207
	A15_SU IN PROJ CPM_Phase	-.139
	A17_PLAN FOR SUPPLIER SUPORT_Pha	-.420*
	A18_PRE-SHIPMENT TESTING_Phase	-.376*
	A19_SU SYSTEM ON ENG DELIVERABLE	-.305
	A2_ REALISTIC STARTUP DURATION F	-.166
	A20_OPERATOR TRAINING PLAN_Phase	-.278
	A21_SPARE PARTS PLAN_Phase	.037
	A22_PRIORITIES & SEQUENCE_Phase	-.403
	A23_ASSESS & COMMUNICATE EFFECTS	-.352*
	A24_PROCEDURES/PROCESS SAFETY MA	-.390*
	A25_SYSTEM TURMOVER PLAN_Phase	-.448*

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Correlations

Statistics	Model Activity	SU_INX
Pearson Correlation	A27_TRANSITION TO SYSTEMS-BASED	-.504**
	A28_CONSTRUCTION-SU TEAM BUILDIN	-.354*
	A29_OPERATOR TRAINING_Phase	.092
	A3_ESTIMATE SU COSTS_Phase	-.070
	A32_PERFORMANCE MEASURES & FINAL	.195
	A4_IMPACT ON ECONOMICS_Phase	-.049
	A5_SU OBJECTIVES_Phase	-.139
	A6_STRATEGY & EXECUTION PLAN_Pha	-.276
	A7_TEAM ASSIGMENTS_Phase	-.512**
	A8_IDENTIFY SYSTEMS_Phase	-.367*
	A9_BUDGET & SCHEDULE_Phase	-.176
	SU_INX	1.000
	SUPER	.415*

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Correlations

Statistics	Model Activity	SU_INX
Sig. (1-tailed)	A1_ SR MANAGEMENT COMMITMENT_Pha	.241
	A10_O&M IMPUT_Phase	.027
	A11_RISKS_Phase	.004
	A12_PROCUREMENT_Phase	.289
	A13_INCENTIVES_Phase	.009
	A14_TEAM BUILDING_Phase	.172
	A15_SU IN PROJ CPM_Phase	.263
	A17_PLAN FOR SUPPLIER SUPORT_Pha	.016
	A18_PRE-SHIPMENT TESTING_Phase	.032
	A19_SU SYSTEM ON ENG DELIVERABLE	.117
	A2_ REALISTIC STARTUP DURATION F	.209
	A20_OPERATOR TRAINING PLAN_Phase	.085
	A21_SPARE PARTS PLAN_Phase	.431
	A22_PRIORITIES & SEQUENCE_Phase	.061
	A23_ASSESS & COMMUNICATE EFFECTS	.042
	A24_PROCEDURES/PROCESS SAFETY MA	.027
	A25_SYSTEM TURMOVER PLAN_Phase	.012
	A27_TRANSITION TO SYSTEMS-BASED	.007
	A28_CONSTRUCTION-SU TEAM BUILDIN	.049
	A29_OPERATOR TRAINING_Phase	.327
	A3_ESTIMATE SU COSTS_Phase	.381

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Correlations

Statistics	Model Activity	SU_INX
Sig. (1-tailed)	A32_PERFORMANCE MEASURES & FINAL	.205
	A4_IMPACT ON ECONOMICS_Phase	.418
	A5_SU OBJECTIVES_Phase	.259
	A6_STRATEGY & EXECUTION PLAN_Pha	.086
	A7_TEAM ASSIGMENTS_Phase	.004
	A8_IDENTIFY SYSTEMS_Phase	.036
	A9_BUDGET & SCHEDULE_Phase	.257
	SU_INX	.
	SUPER	.017

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E.3 EXAMPLE OF BIVARIATE HYPOTHESIS TESTING

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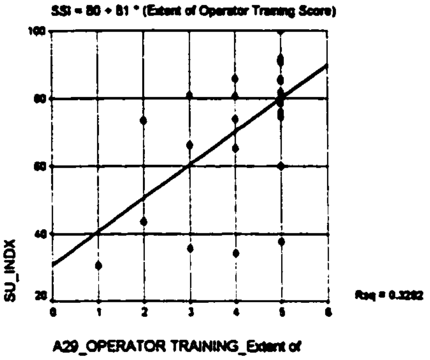
Appendix E.3

Example of Bivariate Hypothesis Testing



Correlations

		SU_INDX	A29_OPERATOR TRAINING_Extent of
Pearson Correlation	SU_INDX	1.000	.573
	A29_OPERATOR TRAINING_Extent of	.573	1.000
Sig. (1-tailed)	SU_INDX	.	.001
	A29_OPERATOR TRAINING_Extent of	.001	.
N	SU_INDX	25	25
	A29_OPERATOR TRAINING_Extent of	25	25

Coefficients[a]

Model		Unstandardized Coefficients			
		B	Std. Error	t	Sig.
1	(Constant)	30.756	12.716	2.419	.024
	A29_OPERATOR TRAINING_Extent of	9.872	2.945	3.352	.003

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Coefficients[a]

Model		Correlations		
		Zero-order	Partial	Part
1	(Constant)			
	A29_OPERATOR TRAINING_Extent of	.573	.573	.573

a. Dependent Variable: SU_INDX

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E.4 EFFORT T-TEST RESULTS

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Effort t-test Results

t-Test: Two-Sample Assuming Unequal Variances

1 SR MANAGEMENT COMMITMENT_		
	V. Success.	V. Unsuccess.
Mean	4.4	3.4
Variance	0.8	3.8
Observations	5	5
Hypothesized Me	0	
df	6	
t Stat	1.04257207	
P(T<=t) one-tail	0.16866055	
t Critical one-tail	1.94318091	
P(T<=t) two-tail	0.33732109	
t Critical two-tail	2.44691364	

2 REALISTIC STARTUP DURATION FORECAST		
	V. Success.	V. Unsuccess.
Mean	4.2	2
Variance	1.2	2.666666667
Observations	5	4
Hypothesized Me	0	
df	5	
t Stat	2.31046214	
P(T<=t) one-tail	0.03443378	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.06886756	
t Critical two-tail	2.57057764	

3 ESTIMATE SU COSTS_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.4	2
Variance	0.8	4.5
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	2.33108607	
P(T<=t) one-tail	0.03356023	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.06712047	
t Critical two-tail	2.57057764	

4 IMPACT ON ECONOMICS_Extent of use		
	V. Success.	V. Unsuccess.
Mean	3.8	3.8
Variance	2.7	4.7
Observations	5	5
Hypothesized Me	0	
df	7	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.89457751	
P(T<=t) two-tail	1	
t Critical two-tail	2.36462256	

5 SU OBJECTIVES_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.6	3.2
Variance	0.3	3.7
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	1.56524758	
P(T<=t) one-tail	0.08914936	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.17829871	
t Critical two-tail	2.57057764	

6 STRATEGY & EXECUTION PLAN_		
	V. Success.	V. Unsuccess.
Mean	4.6	4.2
Variance	0.3	0.7
Observations	5	5
Hypothesized Me	0	
df	7	
t Stat	0.89442719	
P(T<=t) one-tail	0.20039988	
t Critical one-tail	1.89457751	
P(T<=t) two-tail	0.40079976	
t Critical two-tail	2.36462256	

7 TEAM ASSIGMENTS_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.2	4.6
Variance	0.7	0.3
Observations	5	5
Hypothesized Me	0	
df	7	
t Stat	-0.8944272	
P(T<=t) one-tail	0.20039988	
t Critical one-tail	1.89457751	
P(T<=t) two-tail	0.40079976	
t Critical two-tail	2.36462256	

8 IDENTIFY SYSTEMS_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.6	4.2
Variance	0.3	1.7
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	0.63245553	
P(T<=t) one-tail	0.27743914	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.55487828	
t Critical two-tail	2.57057764	

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Effort t-test Results

9 BUDGET & SCHEDULE_Extent of use		
	V. Success.	V. Unsuccess.
Mean	3	3
Variance	0	4.666666667
Observations	2	4
Hypothesized Me	0	
df	3	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	2.35336302	
P(T<=t) two-tail	1	
t Critical two-tail	3.18244929	

10 O&M IMPUT_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.8	4.2
Variance	0.2	1.7
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	0.97332853	
P(T<=t) one-tail	0.18754628	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.37509255	
t Critical two-tail	2.57057764	

11 RISKS_Extent of use		
	V. Success.	V. Unsuccess.
Mean	3.2	3
Variance	4.7	4.5
Observations	5	5
Hypothesized Me	0	
df	8	
t Stat	0.14744196	
P(T<=t) one-tail	0.4432157	
t Critical one-tail	1.85954832	
P(T<=t) two-tail	0.88643141	
t Critical two-tail	2.30600563	

12 PROCUREMENT_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.5	4
Variance	0.5	1
Observations	2	5
Hypothesized Me	0	
df	3	
t Stat	0.74535599	
P(T<=t) one-tail	0.2550701	
t Critical one-tail	2.35336302	
P(T<=t) two-tail	0.5101402	
t Critical two-tail	3.18244929	

13 INCENTIVES_Extent of use		
	V. Success.	V. Unsuccess.
Mean	2.2	1
Variance	5.2	2
Observations	5	5
Hypothesized Me	0	
df	7	
t Stat	1	
P(T<=t) one-tail	0.17530833	
t Critical one-tail	1.89457751	
P(T<=t) two-tail	0.35061666	
t Critical two-tail	2.36462256	

14 TEAM BUILDING_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.4	3.2
Variance	0.8	4.7
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	1.14415511	
P(T<=t) one-tail	0.15218028	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.30436057	
t Critical two-tail	2.57057764	

15 SU IN PROJ CPM_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.2	3.4
Variance	0.7	1.8
Observations	5	5
Hypothesized Me	0	
df	7	
t Stat	1.13137085	
P(T<=t) one-tail	0.14758235	
t Critical one-tail	1.89457751	
P(T<=t) two-tail	0.2951647	
t Critical two-tail	2.36462256	

17 PLAN FOR SUPPLIER SUPORT_		
	V. Success.	V. Unsuccess.
Mean	4.4	4
Variance	0.8	1
Observations	5	5
Hypothesized Me	0	
df	8	
t Stat	0.66666667	
P(T<=t) one-tail	0.26187122	
t Critical one-tail	1.85954832	
P(T<=t) two-tail	0.52374244	
t Critical two-tail	2.30600563	

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Effort t-test Results

18 PRE-SHIPMENT TESTING_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4	3.4
Variance	1.5	2.3
Observations	5	5
Hypothesized Me	0	
df	8	
t Stat	0.6882472	
P(T<=t) one-tail	0.2553787	
t Critical one-tail	1.85954832	
P(T<=t) two-tail	0.5107574	
t Critical two-tail	2.30600563	

19 SU SYSTEM # ON ENG DELIVERABLES		
	V. Success.	V. Unsuccess.
Mean	4	3.2
Variance	1	4.7
Observations	5	5
Hypothesized Me	0	
df	6	
t Stat	0.74926865	
P(T<=t) one-tail	0.24101352	
t Critical one-tail	1.94318091	
P(T<=t) two-tail	0.48202704	
t Critical two-tail	2.44691364	

20 OPERATOR TRAINING PLAN_		
	V. Success.	V. Unsuccess.
Mean	4.6	3.4
Variance	0.8	3.3
Observations	5	5
Hypothesized Me	0	
df	6	
t Stat	1.32517831	
P(T<=t) one-tail	0.11666938	
t Critical one-tail	1.94318091	
P(T<=t) two-tail	0.23333877	
t Critical two-tail	2.44691364	

21 SPARE PARTS PLAN_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.6	4.6
Variance	0.3	0.3
Observations	5	5
Hypothesized Me	0	
df	8	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.85954832	
P(T<=t) two-tail	1	
t Critical two-tail	2.30600563	

22 PRIORITIES & SEQUENCE_		
	V. Success.	V. Unsuccess.
Mean	4.5	2.75
Variance	0.5	4.25
Observations	2	4
Hypothesized Me	0	
df	4	
t Stat	1.52752523	
P(T<=t) one-tail	0.10067304	
t Critical one-tail	2.13184649	
P(T<=t) two-tail	0.20134608	
t Critical two-tail	2.77645086	

23 ASSESS & COMMUNICATE EFFECTS_		
	V. Success.	V. Unsuccess.
Mean	4	4
Variance	0.5	1.5
Observations	5	5
Hypothesized Me	0	
df	6	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.94318091	
P(T<=t) two-tail	1	
t Critical two-tail	2.44691364	

24 PROCEDURES/PROCESS SAFETY MGMT.		
	V. Success.	V. Unsuccess.
Mean	4.8	3.6
Variance	0.2	1.8
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	1.8973666	
P(T<=t) one-tail	0.05812777	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.11625553	
t Critical two-tail	2.57057764	

25 SYSTEM TURMOVER PLAN_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.6	4.2
Variance	0.3	1.7
Observations	5	5
Hypothesized Me	0	
df	5	
t Stat	0.63245553	
P(T<=t) one-tail	0.27743914	
t Critical one-tail	2.01504918	
P(T<=t) two-tail	0.55487828	
t Critical two-tail	2.57057764	

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Effort t-test Results

27 TRANSITION TO SYSTEMS-BASED EXECUTION_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4	4.6
Variance	1	0.3
Observations	5	5
Hypothesized Me	0	
df	6	
t Stat	-1.1766968	
P(T<=t) one-tail	0.14193994	
t Critical one-tail	1.94318091	
P(T<=t) two-tail	0.28387987	
t Critical two-tail	2.44691364	

28 CONSTRUCTION-SU TEAM BUILDING_Extent of use		
	V. Success.	V. Unsuccess.
Mean	2.8	3.2
Variance	1.2	2.7
Observations	5	5
Hypothesized Me	0	
df	7	
t Stat	-0.4529108	
P(T<=t) one-tail	0.33215866	
t Critical one-tail	1.89457751	
P(T<=t) two-tail	0.66431733	
t Critical two-tail	2.36462256	

29 OPERATOR TRAINING_Extent of use		
	V. Success.	V. Unsuccess.
Mean	5	3
Variance	0	2.5
Observations	5	5
Hypothesized Me	0	
df	4	
t Stat	2.82842712	
P(T<=t) one-tail	0.02371033	
t Critical one-tail	2.13184649	
P(T<=t) two-tail	0.04742066	
t Critical two-tail	2.77645086	

32 PERFORMANCE MEASURES & FINAL REPORT_Extent of use		
	V. Success.	V. Unsuccess.
Mean	4.25	2
Variance	0.91666667	4.5
Observations	4	5
Hypothesized Me	0	
df	6	
t Stat	2.11740285	
P(T<=t) one-tail	0.03928244	
t Critical one-tail	1.94318091	
P(T<=t) two-tail	0.07856488	
t Critical two-tail	2.44691364	

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E.5 PHASE T-TEST RESULTS

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Phase t-test Results

t-Test: Two-Sample Assuming Unequal Variances

1 SR MANAGEMENT COMMITMENT_Phase		
	V. Success	V. Unsuccess.
Mean	2.4000	3.0000
Variance	1.3000	0.6667
Observations	5.0000	4.0000
Hypothesized Mea	0.0000	
df	7.0000	
t Stat	-0.9186	
P(T<=t) one-tail	0.1944	
t Critical one-tail	1.8946	
P(T<=t) two-tail	0.3889	
t Critical two-tail	2.3646	

2 REALISTIC STARTUP DURATION FOR		
	V. Success	V. Unsuccess.
Mean	2.4000	3.0000
Variance	0.8000	0.5000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	8.0000	
t Stat	-1.1767	
P(T<=t) one-tail	0.1366	
t Critical one-tail	1.8595	
P(T<=t) two-tail	0.2731	
t Critical two-tail	2.3060	

3 ESTIMATE SU COSTS_Phase		
	V. Success	V. Unsuccess.
Mean	2.2000	2.3333
Variance	0.7000	0.3333
Observations	5.0000	3.0000
Hypothesized Mea	0.0000	
df	6.0000	
t Stat	-0.2661	
P(T<=t) one-tail	0.3995	
t Critical one-tail	1.9432	
P(T<=t) two-tail	0.7991	
t Critical two-tail	2.4469	

4 IMPACT ON ECONOMICS_Phase		
	V. Success	V. Unsuccess.
Mean	3.2000	3.0000
Variance	8.2000	2.0000
Observations	5.0000	4.0000
Hypothesized Mea	0.0000	
df	6.0000	
t Stat	0.1367	
P(T<=t) one-tail	0.4479	
t Critical one-tail	1.9432	
P(T<=t) two-tail	0.8957	
t Critical two-tail	2.4469	

5 SU OBJECTIVES_Phase		
	V. Success.	V. Unsucces
Mean	2.8000	3.2500
Variance	0.7000	1.5833
Observations	5.0000	4.0000
Hypothesized M	0.0000	
df	5.0000	
t Stat	-0.6147	
P(T<=t) one-tai	0.2828	
t Critical one-tai	2.0150	
P(T<=t) two-tai	0.5656	
t Critical two-tai	2.5706	

6 STRATEGY & EXECUTION PLAN_Phas		
	V. Success.	V. Unsucces
Mean	3.4000	4.4000
Variance	0.8000	1.8000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	7.0000	
t Stat	-1.3868	
P(T<=t) one-tai	0.1040	
t Critical one-tai	1.8946	
P(T<=t) two-tai	0.2081	
t Critical two-tai	2.3646	

7 TEAM ASSIGMENTS_Phase		
	V. Success.	V. Unsucces
Mean	3.6000	5.0000
Variance	1.3000	0.5000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	7.0000	
t Stat	-2.3333	
P(T<=t) one-tai	0.0262	
t Critical one-tai	1.8946	
P(T<=t) two-tai	0.0524	
t Critical two-tai	2.3646	

8 IDENTIFY SYSTEMS_Phase		
	V. Success.	V. Unsucces
Mean	3.4000	4.6000
Variance	0.3000	1.3000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	6.0000	
t Stat	-2.1213	
P(T<=t) one-tai	0.0391	
t Critical one-tai	1.9432	
P(T<=t) two-tai	0.0781	
t Critical two-tai	2.4469	

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Phase t-test Results

9 BUDGET & SCHEDULE_Phase		
	V. Success	V. Unsuccess.
Mean	3.5000	4.3333
Variance	4.5000	1.3333
Observations	2.0000	3.0000
Hypothesized Mea	0.0000	
df	1.0000	
t Stat	-0.5077	
P(T<=t) one-tail	0.3505	
t Critical one-tail	6.3137	
P(T<=t) two-tail	0.7009	
t Critical two-tail	12.7062	

10 O&M IMPUT_Phase		
	V. Success	V. Unsuccess.
Mean	2.0000	4.0000
Variance	0.5000	4.0000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	5.0000	
t Stat	-2.1082	
P(T<=t) one-tail	0.0444	
t Critical one-tail	2.0150	
P(T<=t) two-tail	0.0888	
t Critical two-tail	2.5706	

11 RISKS_Phase		
	V. Success	V. Unsuccess.
Mean	2.0000	4.5000
Variance	2.0000	1.0000
Observations	4.0000	4.0000
Hypothesized Mea	0.0000	
df	5.0000	
t Stat	-2.8868	
P(T<=t) one-tail	0.0172	
t Critical one-tail	2.0150	
P(T<=t) two-tail	0.0343	
t Critical two-tail	2.5706	

12 PROCUREMENT_Phase		
	V. Success	V. Unsuccess.
Mean	4.0000	4.4000
Variance	0.0000	1.3000
Observations	2.0000	5.0000
Hypothesized Mea	0.0000	
df	4.0000	
t Stat	-0.7845	
P(T<=t) one-tail	0.2383	
t Critical one-tail	2.1318	
P(T<=t) two-tail	0.4766	
t Critical two-tail	2.7765	

13 INCENTIVES_Phase		
	V. Success.	V. Unsucces
Mean	3.3333	6.0000
Variance	2.3333	2.0000
Observations	3.0000	2.0000
Hypothesized M	0.0000	
df	2.0000	
t Stat	-2.0000	
P(T<=t) one-tail	0.0918	
t Critical one-ta	2.9200	
P(T<=t) two-tail	0.1835	
t Critical two-tai	4.3027	

14 TEAM BUILDING_Phase		
	V. Success.	V. Unsucces
Mean	2.8000	4.2500
Variance	0.7000	0.9167
Observations	5.0000	4.0000
Hypothesized M	0.0000	
df	6.0000	
t Stat	-2.3865	
P(T<=t) one-tail	0.0271	
t Critical one-ta	1.9432	
P(T<=t) two-tail	0.0543	
t Critical two-tai	2.4469	

15 SU IN PROJ CPM_Phase		
	V. Success.	V. Unsucces
Mean	3.6000	4.0000
Variance	2.3000	2.5000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	8.0000	
t Stat	-0.4082	
P(T<=t) one-tail	0.3469	
t Critical one-ta	1.8595	
P(T<=t) two-tail	0.6938	
t Critical two-tai	2.3060	

17 PLAN FOR SUPPLIER SUPORT_Phas		
	V. Success.	V. Unsucces
Mean	3.4000	4.8000
Variance	0.8000	1.2000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	8.0000	
t Stat	-2.2136	
P(T<=t) one-tail	0.0289	
t Critical one-ta	1.8595	
P(T<=t) two-tail	0.0578	
t Critical two-tai	2.3060	

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Phase t-test Results

18 PRE-SHIPMENT TESTING_Phase		
	V. Success	V. Unsuccess.
Mean	2.8000	4.0000
Variance	0.7000	0.5000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	8.0000	
t Stat	-2.4495	
P(T<=t) one-tail	0.0200	
t Critical one-tail	1.8595	
P(T<=t) two-tail	0.0400	
t Critical two-tail	2.3060	

22 PRIORITIES & SEQUENCE_Phase		
	V. Success.	V. Unsucces
Mean	3.5000	5.0000
Variance	0.5000	0.0000
Observations	2.0000	3.0000
Hypothesized M	0.0000	
df	1.0000	
t Stat	-3.0000	
P(T<=t) one-tai	0.1024	
t Critical one-ta	6.3137	
P(T<=t) two-tai	0.2048	
t Critical two-tai	12.7062	

19 SU SYSTEM # ON ENG DELIVERABLES_Phase		
	V. Success	V. Unsuccess.
Mean	3.6000	4.2500
Variance	1.3000	0.9167
Observations	5.0000	4.0000
Hypothesized Mea	0.0000	
df	7.0000	
t Stat	-0.9294	
P(T<=t) one-tail	0.1918	
t Critical one-tail	1.8946	
P(T<=t) two-tail	0.3836	
t Critical two-tail	2.3646	

23 ASSESS & COMMUNICATE EFFECTS		
	V. Success.	V. Unsucces
Mean	4.0000	5.2000
Variance	1.0000	0.2000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	6.0000	
t Stat	-2.4495	
P(T<=t) one-tai	0.0249	
t Critical one-ta	1.9432	
P(T<=t) two-tai	0.0498	
t Critical two-tai	2.4469	

20 OPERATOR TRAINING PLAN_Phase		
	V. Success	V. Unsuccess.
Mean	4.0000	4.6000
Variance	1.0000	1.3000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	8.0000	
t Stat	-0.8847	
P(T<=t) one-tail	0.2011	
t Critical one-tail	1.8595	
P(T<=t) two-tail	0.4021	
t Critical two-tail	2.3060	

24 PROCEDURES/PROCESS SAFETY M		
	V. Success.	V. Unsucces
Mean	3.2000	4.6000
Variance	0.2000	1.3000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	5.0000	
t Stat	-2.5560	
P(T<=t) one-tai	0.0254	
t Critical one-ta	2.0150	
P(T<=t) two-tai	0.0509	
t Critical two-tai	2.5706	

21 SPARE PARTS PLAN_Phase		
	V. Success	V. Unsuccess.
Mean	3.8000	3.4000
Variance	0.7000	0.8000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	8.0000	
t Stat	0.7303	
P(T<=t) one-tail	0.2430	
t Critical one-tail	1.8595	
P(T<=t) two-tail	0.4860	
t Critical two-tail	2.3060	

25 SYSTEM TURMOVER PLAN_Phase		
	V. Success.	V. Unsucces
Mean	3.8000	4.8000
Variance	1.2000	0.2000
Observations	5.0000	5.0000
Hypothesized M	0.0000	
df	5.0000	
t Stat	-1.8898	
P(T<=t) one-tai	0.0587	
t Critical one-ta	2.0150	
P(T<=t) two-tai	0.1174	
t Critical two-tai	2.5706	

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Phase t-test Results

27 TRANSITION TO SYSTEMS-BASED EXECUTION_Phase		
	V. Success	V. Unsuccess.
Mean	4.7500	5.4000
Variance	0.2500	0.8000
Observations	4.0000	5.0000
Hypothesized Mea	0.0000	
df	6.0000	
t Stat	-1.3780	
P(T<=t) one-tail	0.1087	
t Critical one-tail	1.9432	
P(T<=t) two-tail	0.2174	
t Critical two-tail	2.4469	

28 CONSTRUCTION-SU TEAM BUILDING_Phase		
	V. Success	V. Unsuccess.
Mean	5.0000	5.4000
Variance	0.0000	0.8000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	4.0000	
t Stat	-1.0000	
P(T<=t) one-tail	0.1870	
t Critical one-tail	2.1318	
P(T<=t) two-tail	0.3739	
t Critical two-tail	2.7765	

29 OPERATOR TRAINING_Phase		
	V. Success	V. Unsuccess.
Mean	4.8000	4.6000
Variance	0.2000	0.3000
Observations	5.0000	5.0000
Hypothesized Mea	0.0000	
df	8.0000	
t Stat	0.6325	
P(T<=t) one-tail	0.2724	
t Critical one-tail	1.8595	
P(T<=t) two-tail	0.5447	
t Critical two-tail	2.3060	

32 PERFORMANCE MEASURES & FINAL REPORT_Phase		
	V. Success	V. Unsuccess.
Mean	8.0000	7.3333
Variance	0.0000	1.3333
Observations	4.0000	3.0000
Hypothesized Mea	0.0000	
df	2.0000	
t Stat	1.0000	
P(T<=t) one-tail	0.2113	
t Critical one-tail	2.9200	
P(T<=t) two-tail	0.4226	
t Critical two-tail	4.3027	

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Vita

John Stanford McLeod was born in Augusta, Georgia on October 10, 1950, the son of Francis DeKalb McLeod and Dorothy VanLandingham McLeod. After completing high school in El Paso Texas, he entered the University of Texas at El Paso in 1968 and graduated with a Bachelor of Science in 1973. During the following years he was employed as a research assistant at Baylor College of Medicine. In 1975 he entered the Graduate School at the University of Houston and earned a Masters of Science degree in May 1978. For the next 16 years he worked for the consulting engineering firm CH2M Hill on a variety of industrial and municipal projects. In 1994 he entered the University of Texas at Austin to work on his doctorate in Civil Engineering. He is a registered professional engineer in Texas.

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