An Assessment of Implementation Requirements for
The Tier II Construction Workforce Strategy

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An Assessment of Implementation Requirements for
The Tier II Construction Workforce Strategy

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Dedication

This dissertation is dedicated to my wife, Barbara, and to our sons, Jim and John.

Thank you for your constant love, encouragement, and support.
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The United States construction industry has endured a skilled labor shortage over the last two decades. The shortage varies in its characteristics and intensity, but it continues to persist. Although the industry has developed numerous programs to improve recruitment, training, and retention, these efforts have not eliminated the problem. It is clear that more must be done.

The Tier II strategy combines a number of workforce development and management principles into a comprehensive approach that is measurable and can be related to construction success. The strategy seeks to develop a strong, highly-skilled core within the journey-level workforce. These “Tier II journey-level craft workers” possess excellent technical skills and have the management skills to support crew-level planning. Effective utilization of these highly-skilled craft workers should result in better project performance, as well as higher income, job satisfaction, and better career opportunities for the individual worker. The Tier II strategy is defined by metrics
developed to measure performance and to provide guidance for implementation. Baseline data have been collected from more than 900 individuals and 20 projects.

This dissertation documents the first comprehensive attempt to provide quantitative guidance regarding the implementation of the Tier II strategy. The current status of the industry based on the Tier II metrics is assessed using the baseline data. Using this current status as a starting point, this dissertation identifies the requirements necessary to achieve an advanced level of Tier II implementation for an example project, which requires the determination of quantitative data where none exist in the academic literature. Expected benefits and costs are developed based on published literature and unpublished data from a number of industry sources.

Industry implementation will evolve in a number of different forms, as companies develop detailed implementation plans that complement their corporate cultures and the specific requirements of their projects and their personnel.

Based on the Tier II metrics, baseline data, published literature, and unpublished industry data gathered through interviews and meetings, the Tier II strategy can be implemented at an advanced level with a minimum expected benefit-cost ratio in the range of 2:1 to 3:1.
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Chapter 1: Introduction

Construction is one of the largest industries in the United States. It employs more than 5 percent of the nation’s workers and produces 4.4 percent of the nation’s Gross Domestic Product (BEA 2004, BLS 2004b). Despite its size and strength, the industry struggles with a persistent skilled labor shortage, which has been documented by a number of prominent industry organizations throughout the last two decades. The Construction Users Roundtable, an organization of major purchasers of construction, “recognizes that the most critical issue facing the industry is the presence of a skilled workforce shortage.” (CURT 2004b). The National Center for Construction Education and Research observed that “…clients demand increased project quality. Only those contractors with trained and skilled workers capable of meeting that demand will succeed.” (NCCER 2003a).

Many different initiatives have been developed in an effort to address this shortage, but they have generally focused on one or two aspects of the problem and have achieved varied results. Emerging research at The University of Texas at Austin, funded by the Center for Construction Industry Studies, has combined a number of workforce development and management concepts into a more comprehensive approach – the Tier II strategy – which is one potential solution to address the shortage of skilled construction labor in the United States.

1.1 Introduction to the Tier II Strategy

The University of Texas and the Alfred P. Sloan Foundation established the Center for Construction Industry Studies (CCIS) in 1997. One major area of study is the construction workforce, and this effort is guided by the following mission (Tucker, et al. 1999):
• “Characterize the current status of the construction workforce;
• Understand the labor incentives and disincentives;
• Suggest methods to effectively utilize labor as a resource;
• Understand the impact of demographic and technology trends; and
• Determine possible mechanisms to change the value of the workforce.”

In support of this mission, the workforce group has conducted research studies related to multiskilled workers, the use of technology in construction, evaluating innovative construction management methods, and other pertinent subjects. These initial studies provide part of the foundation for the Two-Tier Construction Workforce Strategy.

The Two-Tier strategy seeks to increase the supply of skilled labor through aggressive workforce development, while at the same time decreasing the demand for skilled labor through more effective workforce management. Expected benefits include improving human capital, improving construction project cost and schedule performance, and mitigating the shortage of skilled construction labor in the United States.

The strategy consists of two parts: Tier I, which can be implemented with a workforce of any skill level, and Tier II, which has as its ultimate goal increasing the value of the construction workforce by developing workers whose skill levels are significantly higher than those of the current construction workforce.

The Tier I strategy seeks to develop a strong cadre of field supervision to effectively manage the field workforce. Training for journey-level craft workers and apprentices/helpers is primarily technical in nature and is conducted on a short-term, task-oriented basis. The Tier I strategy addresses the skilled labor shortage primarily from the standpoint of reducing the demand for skilled labor – more effective management should result in better productivity, so that fewer direct labor hours are required to complete the same amount of work.
The Tier II strategy seeks to develop a highly-skilled core within the journey-level workforce. These “Tier II journey-level craft workers” (Tier II JCWs) possess excellent technical skills and management skills to support crew-level planning. Technical training is conducted from a long-term, “craft development” perspective. Individuals are trained and certified in more than one craft, creating more flexibility with respect to personnel and crew assignments. In order to effectively implement Tier II, craft workers need to possess more than the basic knowledge required to do their jobs. Tier II requires “over-educating” to a certain extent, including continuous education and training, management skills, and the use of information technology, in order to upgrade the skills of the workforce as a whole. In addition, crews can adopt a team identity in a collaborative management atmosphere, expanding the span of control of field supervision in the organization (Borcherding, et al. 2001). In short, Tier II seeks to return construction to more of a craft paradigm\(^1\), developing Tier II JCWs who are true “craftsmen” working with greater involvement and autonomy than is common today. Tier II was designed to be implemented within the key crafts – those that have the greatest impact on the cost and schedule performance of the project. This is simply an effort to concentrate the workforce development investment where it can provide the greatest benefit.

The Tier II strategy addresses both demand and supply aspects of the skilled labor shortage. Tier II reduces demand because more extensive training and more collaborative management should result in better productivity, so that fewer direct labor hours are required to complete the same amount of work. Tier II also increases supply because the opportunities for training, additional skills, higher wages, and a more structured career path should improve the image of the construction industry, positively

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\(^1\) Maloney and McFillen (1995) describe the “craft paradigm” in a historical perspective.
impacting recruitment and retention within the industry, while the training improves the skills of the workforce.

The original goals and characteristics of the Tier II strategy include (Borcherding, et al. 2001):

- Similar or lower project construction costs,
- Better safety, quality, productivity, and schedule performance,
- More predictability and less chaos due to effective crew-level planning and scheduling,
- Better worker craft skills, including multiskilled workers,
- Higher hourly compensation,
- More crew autonomy and less administration and supervision,
- Fewer total hires and less turnover on a project,
- Higher loyalty between workers, the project, and the employers, and
- Less attrition in the industry due to defined career path opportunities.

One of the unique aspects of the Two-Tier strategy is its comprehensive approach to the problem. Another is its use of metrics to quantify the skills and experience of individuals, project management practices, and project success. Tier I and Tier II each contain five major components, and metrics were developed to quantify each of these components. Tier I and Tier II Indices were developed to quantify the extent of implementation of each strategy at the project level. The purpose of the metrics is to measure performance and to provide guidance for implementation. The underlying research hypothesis is that more effective implementation of either strategy will result in better construction performance. These strategies, and the metrics, were developed with significant input from more than 50 construction industry professionals, from journey-level craft workers to executives.
Due to Tier II’s emphasis on workforce development, metrics were required to quantify an individual’s technical and management skills. Appendix B contains the Tier II individual metrics.

The Tier II Project Index is comprised of five major components, each weighted equally. Each of the five major components has its own metric, consisting of criteria and weights for each of its various elements. Appendix C contains the Tier II project metrics. The major components are:

- Craft Technical Skills,
- Craft Management Skills,
- Information Technology Utilization,
- Craft Utilization, and
- Organization.

Howard (2001) and Chang (2002) presented detailed descriptions of the development of the Two-Tier strategy and the Tier II metrics. Castañeda-Maza (2002) analyzed the receptiveness of the construction workforce toward the elements of the Tier II strategy. Shields (2002) developed the Construction Phase Success Index, which combines project cost, schedule, quality, and safety performance into a single statistical measurement of success. Shields’ work indicated the potential for improvement in project performance as well – the overall success scores (on a scale of 1 to 10) for 107 industrial projects completed by Construction Industry Institute (CII) member companies ranged from 0.63 to 9.3, with a standard deviation of 2. Brandenburg (2004) presented a detailed description of the development of the Tier I strategy and metrics, as well as an evaluation of the field supervisors’ current skill levels and receptiveness toward the elements of the Tier I strategy.
The strategic plan for the Tier II strategy can be summarized in the following major phases:

1. Define the elements of the strategy,
2. Develop metrics for each element,
3. Collect baseline data,
4. Identify requirements for implementation,
5. Pursue pilot projects, and

Phases 1 through 3 of the strategic plan have been completed. This dissertation is the first attempt at phase 4, identifying the requirements for implementation. Phase 5 is the implementation of Tier II on pilot projects; however, a “road map” is needed to describe what is required to implement these concepts. This dissertation provides such a road map.

1.2 THE CASE FOR IMPLEMENTATION

It is prudent to ask the question, “Why is this needed?” After all, despite the numerous complaints in the industry regarding the shortage of skilled labor, projects continue to be built. There are some instances of adverse cost and schedule impacts, but these cannot be definitively blamed on the skilled labor shortage. However, it becomes clear that action is required when one considers that the shortage persists despite all of the resources invested in scores of different programs over the last two decades in an effort to improve recruitment, training, and retention in the construction industry.

The combination of workforce development and management elements in the Tier II strategy is designed to yield significant benefits at the project level. Borcherding, et al. (2001) list improved productivity, safety, quality, and schedule performance, among others. Productivity improvement case studies indicate that a 20 percent reduction in
total work hours is achievable through the effective management of a skilled workforce (Picard and Seay 1996; Hickok 2003; Pappas, Tucker, and Borcherding 2003). Tier II involves much more than a typical productivity improvement program, and offers a tremendous potential incentive for the organization that decides to capitalize on it.

This section addresses some of the barriers to implementing not only Tier II, but any proactive workforce development strategy. A common overarching barrier to change is the long-standing reluctance to invest in training. The Business Roundtable’s (BRT) Construction Industry Cost Effectiveness Project (CICE) offered the following reasons (BRT 1982d):

1. “Fear of losing a bid due to added training costs.
2. Fear of training employees and losing them to a competitor.
3. Fear of working with a non-proven program.
4. Failure to recognize a need for training, since workers can be pirated from their competitors.
5. Lack of employee acceptance of traditional training programs.
6. Lack of appreciation of the improved productivity that can be realized through training of their workers.”

Owners and contractors are reluctant to train workers who may very well leave their project, in most cases to work for a competitor (CII 1996b). While many workers are mobile due to the nature of the construction industry and the competition for skilled labor, this reluctance is in fact incomplete thinking. Consider a logical alternative: owners and contractors choose to not train their workers, who then stay on the project for the duration. Is it better to have a trained workforce and lose some of that investment, or to build projects with an unskilled workforce because of the fear of losing that investment? Many highly-skilled construction workers rotate between a small number of
employers in order to remain in a certain geographical area or to work with certain people. Phillips (1991) documented the negative impacts of not training on absenteeism, turnover, rework, productivity, and project cost. Although non-union contractors have generally found it more effective to “pirate” workers from competitors than to train them, this has become increasingly more difficult as the supply of skilled labor has tightened.

The inherent difficulty in measuring the benefits of training is another barrier (BRT 1982b; BRT 1982d; Phillips 1991; Glover, et al. 1999). When profit margins are slim, it is easy to reduce expenses in areas where the return is difficult to quantify. This same argument is often made against paying higher wage rates for better skilled workers. However, construction contracts can be structured to focus owner and contractor performance toward total project cost (Pappas 2000), and, to an extent, the resulting performance can overcome this barrier. As an example, consider whether an owner receives greater value from a contractor who does not train its workforce, pays its workers $15 per hour, and completes the project in 150,000 work hours; or one who invests in training, pays its workers $18 per hour, and due to superior technical skill and resource management, completes the project in 120,000 work hours. The 20 percent reduction in total work hours is certainly possible (Picard and Seay 1996; Hickok 2003; Pappas, Tucker, and Borcherding 2003). The reduction in work hours also provides flexibility to achieve earlier completion or to employ a smaller workforce, based on project priorities and site requirements.

The successful implementation of a new training program or any aggressive workforce development program is not easy. Commitment by upper management is essential (BRT 1982b). Owners play a large role in setting expectations in this area. In fact, the Business Roundtable recommended, “Owners should only do business with
contractors who invest in training and maintain the skills of their work force.” (BRT 1997).

1.3 **OBJECTIVES AND HYPOTHESIS**

There is significant industry interest in implementing Tier II, but the implementation requirements have not yet been sufficiently defined. A feasible implementation model must be developed and refined if these concepts are to be widely adopted. This dissertation represents the first comprehensive attempt to provide quantitative guidance regarding the implementation of the Tier II strategy.

1.3.1 **Objectives**

The primary objectives of this dissertation are:

1. Determine the current status of the construction industry based on the Tier II metrics.
2. Provide quantitative guidance regarding the implementation of the Tier II strategy for an example project.
3. Evaluate the expected benefits and costs of achieving an advanced level of Tier II implementation for an example project.

This dissertation is not intended to be a prescriptive implementation manual. Rather, it identifies the requirements necessary to implement Tier II and addresses the expected benefits and costs of implementation. Industry implementation will evolve in a number of different forms, as companies develop detailed implementation plans that complement their corporate cultures and the specific requirements of their projects and personnel.
1.3.2 **Hypothesis**

The following hypothesis is presented in order to guide the focus of this dissertation and to provide a framework to meet the stated objectives:

Hypothesis: The requirements to implement the Tier II strategy at an advanced level can be quantified, and the expected benefits are at least two times the expected implementation cost.

The hypothesis assumes that the full costs and benefits will be incurred during the example project, in order to provide a consistent evaluation. In reality, the implementation of Tier II is a long-term strategy, and one would reasonably expect that the costs would be amortized over more than one project, and that more than one project would be required to achieve the full benefit of such a strategy.

1.4 **Scope**

The scope of this dissertation is direct-hire industrial construction projects in the United States. The baseline data were collected from workers at 20 projects volunteered by CII member companies. This study focuses on Tier II implementation within key crafts on a project level. The details of the implementation requirements are based on the assumptions of the 1996 CII Model Plant staffing exercise (CII 1998), which provides the example project and workforce for this study.

1.5 **Dissertation Organization**

This chapter presented an introduction to the Tier II strategy and the scope and objectives of this dissertation. Chapter Two presents relevant background information concerning the construction industry, the skilled labor shortage, previous studies related to the elements of the Tier II strategy, and industry efforts to address the shortage. Chapter Three describes the methodology of the study. Chapter Four presents the Tier II
Baseline at the project level, defines the workforce for the example project, and addresses some practical aspects of Tier II implementation. Chapter Five presents the detailed development of the level of effort and associated costs required to implement Tier II at an advanced level on the example project. Chapter Six identifies and quantifies the expected benefits of an advanced level of Tier II implementation on the example project. Chapter Seven summarizes the expected benefits and costs and provides a benefit-cost analysis. Chapter Eight provides conclusions and recommendations for further research.
Chapter 2: Background

Considerable information is available regarding the various elements included in the Tier II strategy. This chapter presents relevant information in order to provide a background and context for the assessment of implementing Tier II at an advanced level.

2.1 The Construction Industry

Although the United States construction industry is one of the nation’s largest, it is a fragmented industry, composed of more than 790,000 individual companies. The majority of the firms in the industry are specialty trade contractors. Approximately half of the construction workers in the United States are employed by companies which have between 10 and 99 employees, and 80 percent of construction firms employ fewer than 10 people (BLS 2004b). In 2002, construction workers earned an average of $712 per week, and the median construction worker earned $605 per week (BLS 2004a, BLS 2004b).

The Building and Construction Trades Department (BCTD) of the American Federation of Labor-Congress of Industrial Organizations (AFL-CIO) consists of 15 affiliated unions. Of the nation’s 7 million construction workers, 16 percent are union members, and another 0.7 percent are represented by unions. Government statistics indicate that union members earn significantly more money than their non-union counterparts – median weekly earnings in 2003 were $884 for union members and $873 for those represented by unions, compared to $580 for non-union members (BLS 2004a).

The fragmentation in the industry makes it difficult to establish nationwide standards, such as technical skill standards and training programs. It also makes reliable data collection difficult. This dissertation relies on data collected from U.S. government sources, industry sources, and previous research. It is important to remember that the
results of a particular study only represent the segment(s) of the industry that participated in that study; comprehensive data for the entire industry are rarely available (Tucker, et al. 1999).

The success of any given construction project is inseparably tied to the performance of field labor on that project. Once a project begins the construction phase, field labor is the largest remaining variable that can be controlled or affected by project management (CII 1987).

2.2 THE CONSTRUCTION SKILLED LABOR SHORTAGE

The construction industry has experienced a shortage of skilled labor over the last two decades. The shortage is caused by a number of factors, including a working environment that many consider to be undesirable, relatively low pay and benefits, the generally poor image of the construction industry and its workers, unclear career paths in construction, and the transient nature of the work (Tucker, et al. 1999).

The current skilled labor shortage was predicted by The Business Roundtable (BRT) in its Construction Industry Cost Effectiveness Project (CICE) Summary Report: “The consequence of contractor apathy plus a considerable amount of ignorance among owners about the [training] situation is a looming shortage of trained craftsmen that may well sharply limit the capability and growth of open shop construction later in the Eighties. Indeed the shortage may affect union construction as well.” (BRT 1983). This warning was repeated in the Department of Labor’s 1988 “Workforce 2000” study. CII addressed ways to counter the skilled labor shortage in “Projects and Competition of the Future” (CII 1992b).

The Business Roundtable surveyed its 200 member companies (facility owners) in late 1996 regarding the skilled labor shortage. More than 60 percent reported having experienced a shortage, and 75 percent reported that the situation had worsened over the
previous 5 years. Of those experiencing shortages, 25 percent reported “serious project impacts in cost overruns and/or schedule delays.” The shortage was widespread—geographically (although in pockets), by industry sector, and by craft. The impact in some sectors was severe; almost 90 percent of the chemical and petrochemical facility owners were affected. The poor image of the industry was cited as having the largest impact on recruiting new workers into the construction industry. Craft training and development was cited as having the largest impact on the career path of an individual, and therefore, on retention (BRT 1997).

CII surveyed 1,200 construction workers from its member companies (facility owners and contractors) in 1998. The individuals cited the following barriers to attraction and retention programs: poor industry image, lack of effective company career development programs, lack of participatory management, and job site conditions (CII 1999). From the companies’ viewpoints, 70 percent reported nationwide shortages of skilled craft workers, and most stated that the situation had worsened in the previous two years (CII 2000).

The Construction Users Roundtable (CURT), the successor organization to The Business Roundtable, conducted a Workforce Development Survey in the summer of 2001 to follow-up on the BRT survey of 1996. In this most recent survey (CURT 2001), 82 percent of the respondents reported shortages and 78 percent said that the trend had worsened over previous 3 years. Of those experiencing shortages, 73 percent reported a “moderate to significant” impact (increased cost, schedule delays, use of incentives, and/or projects cancelled) on projects, and 53 percent stated that the overall skill levels of the construction workforce had declined. Table 2.1 summarizes the responses from the 1996 (BRT), 1998 (CII), and 2001 (CURT) surveys for comparison.
Table 2.1: Responses to Industry Workforce Surveys

<table>
<thead>
<tr>
<th>Response</th>
<th>1996 (BRT)</th>
<th>1998 (CII)</th>
<th>2001 (CURT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respondents reporting shortages.</td>
<td>60%</td>
<td>70%</td>
<td>82%</td>
</tr>
<tr>
<td>Respondents reporting that the trend had worsened in the past 2-5 years.</td>
<td>75%</td>
<td>“most”</td>
<td>78%</td>
</tr>
<tr>
<td>Respondents reporting moderate to significant impact on projects.</td>
<td>25%</td>
<td>N/A</td>
<td>73%</td>
</tr>
</tbody>
</table>

The shortages reported in 1996 were widespread with respect to geography, industry sector, and craft; those in 2001 were even more so. Electricians, pipe fitters, and welders were the crafts most affected. Because these are considered key crafts on nearly all heavy industrial projects, this finding is extremely relevant to this dissertation.

The shortage continues to be an important issue in the industry: Construction workers are “[l]ikely to be in short supply” in the next decade, in part due to the retirement of 40 percent of the current workforce (Kiplinger 2002, H2H 2004). “All owners agree that the most critical issue facing the construction industry today is the growing gap between the demand and supply of skilled construction labor.” (CURT 2001). The much-publicized career ratings guide continues to indicate that construction careers are not viewed as desirable – obviously a key factor affecting recruitment. In the 2002 version, construction occupations ranged from #182 (construction foreman) to #247 (ironworker) out of 250 jobs in an evaluation that considered salary, stress, work environment, career outlook, security, and physical demand (Krantz 2002). Finally, the U.S. Department of Labor predicted that construction employment – “the only goods-producing sector in which employment is projected to grow” – will increase by 15 percent between 2002 and 2012 (BLS 2004e).

There are a number of possible solutions to the shortage, and many have been attempted by individual companies and organizations over the years: improving the
image of the construction industry, increasing pay (hourly wage rates, as well as initiatives that do not increase wage rates such as guaranteed overtime and various incentive/bonus programs), providing training incentives, importing foreign labor, and reducing demand for labor through the use of automation and technology.

A notable example is the formation of the National Center for Construction Education and Research (NCCER) by a number of contractors and construction associations in 1995 to “address the severe workforce shortage facing our industry and to develop standardized construction, maintenance and pipeline curricula.” (NCCER 2004a). NCCER training curricula are generally considered as the technical training standard in the non-union industrial sector.

A more recent development is the outsourcing of construction work to foreign sources, exemplified by the construction and transportation of more than 2,000 precast concrete panels by a Mexican firm for the façade of the new Salt Lake City, Utah library (Millman 2004).

The labor shortage may very well be exacerbated by the tendency of owners and contractors to have unrealistic expectations regarding the cost of a project. A company attempting to hire a construction workforce for a project that was approved based on unrealistic expectations is obviously limited in the wage rates it can offer, and the quality of labor available at that wage rate rarely produces the productivity targets and/or the first-time quality of work needed in order to meet the unrealistic budget. Raising wages to attract labor has the undesired effect of further raising the productivity (output per work hour) required to meet the project’s cost goals. Thorough pre-project planning can prevent this problem by producing a detailed scope of work which provides the basis for realistic cost and schedule estimates (Gibson and Pappas 2003).
The historical and current information available indicates that there is indeed a skilled labor shortage at the wage rates owners and contractors are currently willing and/or able to pay.

2.3 **THE TWO-TIER CONSTRUCTION WORKFORCE STRATEGY**

A number of academic studies and industry efforts address one or more aspects of the construction skilled labor shortage. The Two-Tier Construction Workforce Strategy was developed as a more comprehensive approach to the problem.

2.3.1 **Previous Studies – Strategic Issues**

It is valuable to summarize some of the previous economic and construction research that led to the development of the Two-Tier strategy.

In the last decade, former U.S. Secretary of Labor Ray Marshall described “high performance work systems” in the context of a national economic policy. In a 1991 presentation, Marshall cited “the lack of sufficient education and training for front-line workers” as the major cause of the United States’ global economic difficulties. Marshall pointed out that there are really only two ways to compete in the modern global economy: “reduce wages and income, or increase productivity and quality.” From the individual worker’s viewpoint, the only way to increase total income while earning reduced wages is to work more hours (Marshall 1992). However, “[t]he high-wage, high productivity option, by contrast, could create very steep learning and earning curves, and therefore holds greater promise for personal, organizational, and national advancement.” (Marshall 1996). At a national level, choosing to pursue a low-wage strategy is futile because “there is always some country, some other place, with lower wages” (Marshall 1992).
Marshall detailed the following necessary characteristics of high performance organizations, and stressed that they “have to operate together as a unified and coordinated whole” (Marshall 1992):

1. “[T]he effective use of all company resources in order to achieve continuous improvements in productivity.”
2. “[A]n acute concern for the quality of products and services.”
3. “[A]n effective and participative management style – with the emphasis on participative.”
4. “[I]nternal and external flexibility.”
5. “[A] positive incentive structure that builds worker commitment.”
6. “[T]he development and use of leading-edge technology.”
7. “[W]ell-trained and well-educated workers who have the capacity and opportunity to make leading-edge technology function at optimal levels of productivity.”
8. “[A]n effective industrial relations system.”

Marshall (1996) acknowledged barriers to the implementation of such a strategy in the United States, including the tendency of management to focus on short-term interests rather than consider an approach that in the long term will prove to be more valuable, the reluctance of management to share “power” and information with workers, the resources required to train management and workers to successfully operate in this environment (at least five percent of payroll), and the difficulty in quantifying the benefits of the training and of the system. Despite these barriers, other countries have pursued this approach, and there is great potential in it. “The full high-performance production system model as defined in this chapter has never been evaluated. However, partial evaluations of its main components suggest that: (1) human capital investments
produce high returns...better coordination of work, smaller ratios of supervisors to workers, lower rates of machine breakdown, a higher level of machine technology, and more timely delivery of products... (2) worker participation greatly improves productivity and quality, especially when combined with positive reward systems.” (Marshall 1996).

Maloney (1997) addressed construction human resource management from a strategic perspective. He advocated that construction organizations pursue a deliberate human resources strategy and described two prototype strategies. One strategy was based on workers who received strictly skill-based technical training, earned market rate base pay, and worked in a strict hierarchical organization. The other was based on workers who received broader craft-based technical training, as well as training in subjects beyond technical skills; earned pay based on their knowledge and performance; worked in self-managing work teams; and were involved in continuous education and training as part of a formal career path and career development program.

Maloney and McFillen (1995) discussed the potential for better performance when properly equipped and motivated workers are assigned satisfying job tasks in a more autonomous environment. Based on surveys of 650 union and 407 non-union construction workers, Maloney and McFillen determined that the most satisfying job tasks are “whole” pieces of work that require individuals to use a number of their skills and talents. The most rewarding environment is one in which the individual realizes the impact of the work, has a high degree of “freedom, independence, and discretion...in scheduling and performing the work,” and receives proper feedback on the quality and performance of the work. Individuals must be properly equipped to handle these challenging tasks, or they will become overwhelmed and frustrated. This requires knowledge and skills, a desire for a challenge, and relative satisfaction with other areas of their work situation (e.g., pay, general job conditions, coworkers, supervisors, etc.).
benefit of such an approach is that “management would receive both high quality and quantities of work with less need for close supervision, and workers would be permitted to perform more rewarding work resulting in higher work satisfaction and reduced turnover and absenteeism.”

Pappas (2000) studied different construction management methods promoted by their advocates as innovative. The methods were developed for different purposes, but the unexpected similarities between them proved to be important. Common factors across the methods included unusually “extensive communication and coordination between contractor personnel” and “unusually low…delays as measured by the foreman delay survey.” The most significant finding was the fact that despite their differences, each innovative management method addressed five common elements – communication, empowerment, metrics, planning, and training – and “emphasized preparatory activities in order to facilitate the work in the field.” A natural extension of this finding is that if one were to develop or improve a construction management method, that method should address these common elements in some manner.

2.3.2 Conceptual Development

The Two-Tier strategy combines workforce development and workforce management principles into a comprehensive approach that is measurable and can be related to construction success. It addresses some of the major barriers to recruitment and retention noted in the industry workforce surveys, including the importance of craft training and development, the lack of effective company career development programs, and the lack of participative management (BRT 1997, CII 1999). The two tiers in the strategy somewhat reflect Marshall’s concept of low wage/low performance and high wage/high performance work systems, and Maloney’s concept of two strategic approaches to construction human resource management. The strategy addresses the
common elements of innovative construction management methods described by Pappas (2000): communication, empowerment, metrics, planning, and training.

The Tier II strategy pursues Marshall’s concept of a high wage/high performance work system. It is a long-term approach because significant changes are required in order to improve the skill level of the workforce to the extent defined by the strategy.

2.3.3 Development of the Tier II Metrics

The CCIS Workforce Research Team worked with its industry steering committee, a group of 13 executive-level construction professionals, during the second half of 2000 to define the characteristics of the Tier II strategy and develop a draft set of elements for the metrics. CCIS hosted 31 management- and executive-level industry professionals at a February 2001 workshop to review and collect feedback regarding these elements. The steering committee and research team then finalized the elements and assigned weights to each element using the Analytical Hierarchy Process. CCIS hosted a second workshop for 21 experienced craft-level industry professionals in July 2001 to test the metrics and collect further data for weighting the elements (Chang 2002).

Table 2.2 reflects the major components of the Tier II Index:

<table>
<thead>
<tr>
<th>Individual Metrics</th>
<th>Project Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Technical Skills</td>
<td>Project Craft Technical Skills</td>
</tr>
<tr>
<td>Individual Management Skills</td>
<td>Project Craft Management Skills</td>
</tr>
<tr>
<td>Information Technology Utilization</td>
<td></td>
</tr>
<tr>
<td>Craft Utilization</td>
<td>Organization</td>
</tr>
<tr>
<td>Tier II Project Index</td>
<td></td>
</tr>
</tbody>
</table>
Note that there are both individual and project metrics, which are provided in Appendix B and Appendix C, respectively. The two major components of the individual metrics and the five major components of the project metrics are each evaluated on a scale of 1-100. A “Tier II craft worker” is defined as an individual who scores at least 150 of the possible 200 points on the individual metrics in Figures 2.1 and 2.2.

Figure 2.1 indicates the requirements for individual technical skills, consisting of craft certification, multicrafting, experience, and continuous education and training.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Craft Certification</strong></td>
<td>4.0</td>
<td>Certified in 3 crafts.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 2 crafts.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certification.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Technical Experience</strong></td>
<td>4.0</td>
<td>More than 10 years of experience at the certified craft</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>level.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 years of experience at the certified craft level.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 1 year of experience at the certified</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>craft level.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Continuous Training and Education</strong></td>
<td>2.0</td>
<td>More than 200 hours of training and skill updating in the last 3 years.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 hours of training and skill updating in the last 3 years.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training or skills updating since first craft</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>certification.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.1: Tier II Individual Technical Skills
Figure 2.2 indicates the requirements for individual management skills at the Tier II journey-level craft worker organizational level.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative</td>
<td>1.0</td>
<td>Certified in at least 4 administrative skills.</td>
<td>10</td>
<td><strong>10</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 2 administrative skills.</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certified administrative skills.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Computer</td>
<td>1.0</td>
<td>Certified in at least 5 computer skills.</td>
<td>10</td>
<td><strong>10</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 3 computer skills.</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certified computer skills.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Planning</td>
<td>3.0</td>
<td>Certified in planning skills.</td>
<td>10</td>
<td><strong>30</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>160 hours of training but not certified in planning skills.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training and certification.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Job Management</td>
<td>2.0</td>
<td>Certified in job management functions.</td>
<td>10</td>
<td><strong>20</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>160 hours of training but not certified in job management functions.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training and certification.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Work Record</td>
<td>3.0</td>
<td>Superior in all categories.</td>
<td>10</td>
<td><strong>30</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superior in some, modest in others.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak in most categories.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.2: Tier II Individual Management Skills

The particular skills desired in each element were identified by Borcherding, et al. (2001):

- Administrative skills: cost management, scheduling, material management, RFI management, and estimating.
- Computer skills: email/internet, word processing, spreadsheet, scheduling, estimating, CAD, and material management.
- Planning skills: material, equipment, tools, information, short-term planning, and scheduling.

- Job management functions: crew coordination, inter-and intra-craft coordination, selection of work means and methods, and leadership.

The average of the individual metric scores for all participating personnel (foremen and journey-level craft workers) are inputs into the Project Craft Technical Skills and Project Craft Management Skills components, shown in Figures 2.3 and 2.4.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score from Individual Evaluation on Technical Skills *</td>
<td>7.0</td>
<td>Greater than 75 points.</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 points.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 25 points.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>% of Tier II workers</td>
<td>3.0</td>
<td>40% or more of journeymen are certified as Tier II workers.</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% of journeymen are certified as Tier II workers.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 10% of journeymen are certified as Tier II workers.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

* For project's key crafts.

Figure 2.3: Tier II Project Craft Technical Skills component

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score from Individual Evaluation on Management Skills *</td>
<td>10.0</td>
<td>Greater than 75 points.</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 points.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 25 points.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

* For project's key crafts.

Figure 2.4: Tier II Project Craft Management Skills component
The utilization of information technology in Tier II, shown in Figure 2.5, includes not only the automation of project information, but the electronic integration of various components of information, to prevent problems due to multiple handling and data entry errors. The information must be made available to Tier II JCWs for it to be of practical use to them. The “high end” of the hardware scale is a wearable computer with a wireless connection to allow the Tier II JCW real-time access to current project information in a rapidly changing environment.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Information Access</td>
<td>6.0</td>
<td>All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically.</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information* is not directly accessed by Tier II workers.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>4.0</td>
<td>Tier II workers have wireless, wearable computers.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hardware is nearby and shared among crews.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No hardware is available to Tier II workers.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills.

Figure 2.5: Tier II Project Information Technology Utilization component
The Craft Utilization index, shown in Figure 2.6, addresses the concentration of Tier II JCWs and multiskilled craft workers in the key crafts. Turnover is also an important measure; the effective utilization of highly-skilled (Tier II) and multiskilled human assets should reduce the number of required total hires for a project.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crew Mix</strong></td>
<td>4.0</td>
<td>Key crafts' crews (on avg.) have at least 40% of Tier II workers.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Key crafts' crews (on avg.) have at least 20% of Tier II workers.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 50% of key crafts' crews have Tier II workers.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Use of Multiskilled Workers</strong></td>
<td>2.0</td>
<td>Key crafts' crews (on avg.) have at least 40% multiskilled workers.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Key crafts' crews (on avg.) have at least 20% multiskilled workers.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 50% of key crafts' crews have multiskilled workers.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Worker Turnover (Total Hires / Peak Workforce)</strong></td>
<td>4.0</td>
<td>Less than 2.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equal to 3.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Greater than 4.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.6: Tier II Project Craft Utilization component
Finally, the Project Organization index, Figure 2.7, assesses the practices regarding communication and the delegation of authority on the project.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>6.0</td>
<td>Proactive information flow to and from workers about the project, established formal &amp; informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project.</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>High Performance Work Place</td>
<td>4.0</td>
<td>Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management skills and IT information available thru Tier II workers.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hierarchical structure, but with 2-way information &amp; idea flow between crews and management.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid hierarchical structure.                                                                 paraphrasing</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2.7: Tier II Project Organization component

The project’s score is summarized in a Tier II Project Index, which is the sum of the five project-level components (Figures 2.3 through 2.7) divided by 50, and indicates the extent of Tier II implementation on a scale of 1-10.

The metrics were field-tested by 29 craft workers at a combined-cycle power plant in the southeast United States in October 2001. In the July 2001 workshop and at this first project, the participants were given the individual metrics in Appendix B and asked to evaluate themselves based on those metrics. The research team decided in
February 2002 to develop a questionnaire and a database to collect and store elemental data (e.g., specifically how many and which crafts an individual is certified in, rather than simply the metric score of 0-10 for craft certification). This created the opportunity to perform more in-depth demographic analysis of the data, some of which was presented by Castañada-Maza (2002) and Brandenburg (2004), some is presented in this document, and much remains to be analyzed. The team also found that collecting elemental data from participants takes less time and eliminates the need for participants to interpret the Tier II individual metrics, some of which require interpolation. Appendix D contains the questionnaires used to collect the individual and project data.

2.3.4 Baseline Data Collection

The research team collected data from individuals at 15 non-union and 5 union project site visits between October 2001 and December 2002. The CCIS workforce database consists of 888 “clean” data points, 837 of which are journey-level craft workers and supervisors, and 770 of which are journey-level craft workers and foremen. These data are considered “baseline” data, because they represent the state of the industry prior to any structured effort to implement Tier I or Tier II. The same elemental data were used to establish the Tier I Baseline (Brandenburg 2004) and the Tier II Baseline presented in Chapters Four and Five of this dissertation.

The projects were volunteered through contacts from CII, various conference presentations, and CII Project Team 182, “Addressing the Shortage of Skilled Craft Workers in the U.S.” The research team negotiated with project management regarding the number of people from key crafts that would participate. Key crafts were defined to project management as those crafts that had the greatest impact on the cost and schedule performance of the project. The company sponsoring the visit determined the key crafts for the project and which individuals would complete the questionnaire. The
questionnaire responses are self-reported and unfiltered. Therefore, the data are not random in a pure statistical sense, but the number of individual responses is large enough to treat the data as representative of the projects visited.

Castañada-Maza (2002) analyzed worker receptiveness to the principles embedded in Tier II and reported that they are generally receptive to improving their individual skills and working in the management environment described by Tier II.

Brandenburg (2004) analyzed supervisor skill levels in the context of the Tier I strategy, and concluded that they are generally competent, capable, and receptive to performing in a Tier I environment. She pointed out, however, that contractors generally do not provide significant amounts of training to field supervisors.

2.4 RELATED PREVIOUS STUDIES

The Tier II strategy integrates a number of familiar workforce development and management principles; however, previous studies largely concentrated on only one or two of these aspects. These previous studies are organized to reflect the five major components of the Tier II Index.

2.4.1 Craft Technical Skills

Technical training is an important factor in managing the skilled labor shortage, in terms of productivity, but also in terms of recruiting and retention – nearly 75 percent of the respondents to the CURT survey stated that a craft training program increased their ability to recruit and retain employees (CURT 2001).

The U.S. Department of Labor created the Bureau of Apprenticeship and Training (BAT) based on the 1937 National Apprenticeship Act. BAT training standards are currently implemented by State Apprenticeship Councils in twenty-nine states. Participation in one of the joint labor/management apprenticeship programs is the most
structured method of entry into the construction industry. These programs are well-established but attendance has declined due to the decreasing accession into the construction industry as a whole, as well as the declining market share of the union sector.

The merit shop or non-union sector of the industrial construction industry essentially began in the 1950s. As demand for non-union construction increased in the 1970s, a few large contractors developed their own in-house training programs, but the majority of the non-union sector’s training needs at that time were met by the union-trained craft workers who worked for non-union contractors.

The Associated Builders and Contractors (ABC), in conjunction with the Merit Shop Foundation and NCCER, began to develop a construction technical training curriculum called the *Wheels of Learning* in 1979. The initial course development was funded by ABC member companies. This curriculum has been continually upgraded and is now known as the Contren® Learning Series (Contren® 2004).

The Construction Industry Cost Effectiveness project (CICE) analyzed current (early 1980s) union and non-union training programs and issued a number of warnings with respect to technical training in the construction industry, particularly in the non-union sector. At that time, the construction volume in the United States was approximately 60 percent non-union and 40 percent union. Non-union training programs experienced a dropout rate of approximately 50 percent, and produced less than 10 percent of the craft workers completing construction craft training. The report predicted a “long-term deterioration in the quality and productivity of the construction work force” if the non-union sector did not significantly increase its training efforts. The report also addressed the need for a standardized training curriculum and the means to fund craft training in the non-union sector (BRT 1982d).
NCCER currently uses a network of accredited training sponsors and instructors to offer training courses and the National Craft Assessment and Certification Program (NCACP). The NCACP is an important part of the overall effort to improve the standardization, and thus the portability, of NCCER training records. It is comprised of two parts – the skills assessment, which is a written examination of the individual’s knowledge, and the performance verification, which is a “hands-on” test of the individual’s practical abilities to perform tasks. A craft worker passing the written portion is referred to as “Certified (Written).” A craft worker passing the performance verification portion is referred to as “Performance Verified.” A craft worker passing both the skills assessment and the performance verification is referred to as “Certified Plus.” Individuals who do not pass the written test receive a “training prescription” and an “Individual Development Plan” to correct deficiencies, which is accomplished through “upgrade training” (NCCER 2003a, NCACP 2004). It is important to note that the union sector uses the term “upgrade training” to describe training completed after achieving certified journey-level status, so care must be taken to properly understand the term “upgrade training” in the context of its use.

There is some question regarding the current extent of union and non-union training programs. Approximately half of the respondents to the CURT survey utilized union apprenticeship training, and half used other programs such as the ABC/NCCER Wheels of Learning (CURT 2001). A study by the Building and Construction Trades Department of the AFL-CIO stated that union training programs produced approximately 75 percent of the graduates of U.S. apprenticeship programs between 1997 and 2001 (BCTD 2003). NCCER’s website claims 209 Accredited Assessment Centers, 33,753 Craft Evaluations completed, and 13,393 Performance Verifications completed as of December 31, 2002 (NCACP 2004).
2.4.2 Craft Management Skills

As mentioned previously, field labor is the single largest variable in the construction phase that can be controlled by project management (CII 1987). A host of research – including Rogge and Tucker (1982), Tucker, et al. (1982), Pappas (2000), and Hickok (2003) – shows that productivity gains (and losses) are impacted to a greater degree by the management and planning of the work than by the direct actions of craft workers. Picard (1998) observed, “On construction projects, small details gone awry can collectively kill productivity; for instance, time wasted on craftsmen hunting for tools, parts, or information.” Evans (1999) echoed this observation: “The most cost-effective impact the management team can have on a project is to provide the required resources to the [field crews].” These resources include the tools, information, materials, and equipment needed to complete the assigned work.

A number of terms are used in the industry to describe the process of identifying, coordinating, and delivering these resources; this dissertation uses the term “short-interval planning.” The key to effective short-interval planning is that it is done well and in a timely manner. One contractor calls it “performance-driven construction,” and its goal is to provide everything to the field crews when it is needed, in order to reduce delays and improve productivity (Cherne 2004). Who performs the particular short-interval planning tasks is, to a large extent, a matter of organizational choice. Pappas, Tucker, and Borcherding (2003) documented one case study in which short-interval planning was primarily done by field engineers, and another in which it was primarily done by foremen. Both systems were effective, because the planning was thorough and was completed in a timely manner.

The majority of the published research discusses management activities appropriate to the crew level (e.g., short-interval planning, scheduling, and resource
acquisition) in the context of field supervision. In the Tier II strategy, Tier II JCWs are also capable of performing these activities.

CICE studied the existing (early 1980s) state of the art supervisor training programs and summarized key points for developing effective programs. The project cited the inability of first- and second-level construction supervisors to plan work, communicate with their crews, and effectively direct work as a significant factor in decreasing construction cost effectiveness. The study called for more formal training in these areas to improve construction productivity (BRT 1982b). Findings related to the management and planning of work included:

- “[T]he inability of foremen to plan work, communicate with workers and direct work activities adequately is judged by CICE study teams to be an important contributor to declining cost effectiveness in construction.” (BRT 1983).
- The productivity of field labor “to a large extent hinges on the skills of first and second level supervisors in communicating with individual workers, and in planning and laying out the work. Such skills can be improved by formal training.” (BRT 1982b). In Tier II, this is done by both foreman and Tier II JCWs.
- There is a general lack of foreman training, especially regarding management skills (BRT 1983). It stands to reason that because management training at the foreman level continues to be rare (Brandenburg 2004), it is even more so at the journey level.
- “The missing element [in foreman and general foreman training] is … too little schooling in such supervisory techniques as communicating with workers and planning their work.” (BRT 1983).
- Factors that “de-motivate” workers include typical problems attributed to incomplete short-interval planning (e.g., lack of proper materials, tools, etc.) and it is often more effective to avoid these “de-motivators” than it is to motivate the workforce (BRT 1983).

- Common elements in good training programs include planning, organizing work, scheduling, safety, quality control, directing and coordinating, material control, human relations, motivation, leadership, effective communications, and problem solving and method improvement (BRT 1983).

- Supervisory skills training is more effective when it is made an integral part of project management, supported by the owner, and conducted on a continuous basis (BRT 1982b).

The Lean Construction Institute focuses on the control and predictability of the flow of work (Howell 1999). As a result of this focus, it developed the Last Planner System®, a structured short-interval planning process, and a metric called Percent Planned Complete (PPC) to quantify the accuracy of that process. PPC is the percentage of tasks scheduled for a particular week that were actually completed in that week. The emphasis on the reliability of the weekly work plan has proven to be very effective. Pappas (2000) documented one successful Last Planner® case study as an example of an innovative management method. In a broader, subsequent study, Kim (2002) concluded that projects using the Last Planner® experienced significant improvement in project performance. Many of the concepts surrounding the Last Planner® and PPC, and their application to industrial piping, are found in “Managing Uncertainty in the Piping Function” (CII 1996a).
In addition to short-interval planning tasks, the Tier II individual management metrics include skills related to administrative and document management tasks. The Construction Owners Association of Alberta includes these skills as part of its essential skills training program (COAA 2004).

A large amount of literature links the management of the project to retention and turnover. Picard (1998) stated, “An efficient and effective work process causes not only customer delight and contractor competitiveness, but also job satisfaction.” Bernstein (2003) stated, “Better workforce management will lead to increased retention of skilled labor.” The author has documented, as a consultant on a number of domestic industrial and building projects since 1999, the impacts – predominantly frustration and turnover – felt by individual crewmembers when project resources are not managed well.

Edward (2001) presented a theoretical discussion of the distribution of management skills within a self-managed Tier II crew. He concluded that the minimum requirement for the crew to operate successfully is that all management areas must be represented in the crew as a whole. He recommended “the gradual introduction of structured modules of these skill sets” and proposed rotating team leadership as a means to develop management skills through practical application.

2.4.3 Information Technology

Information technology (IT) and its effective utilization has become a significant factor in the operation of almost all businesses. Eighty percent of information technology managers at process and power companies stated that information management was “critical to competitiveness” (Phair and Powers 1998). The construction industry is no different. El-Mashaleh (2003) studied 74 construction firms and found positive correlations between IT use and composite firm performance, schedule performance, and cost performance.
CCIS conducted an industry-wide benchmarking effort to quantify “the extent to which task integration and task automation (IA) technologies are being used in executing capital facility projects.” (O’Connor, et al. 2000). The research team collected and analyzed data from 209 projects in the United States in 1998 and 1999, and quantified the use of IA on industrial projects during the construction management and construction execution phases as 3.3 on a 0-10 scale. O’Connor also pointed out that the automation of an individual task normally precedes integration “for two reasons: 1) it is generally easier to automate an isolated task than to automate task-to-task linkages that involve several different organizational units; and 2) task-to-task integration is facilitated (or made easier) when task automation is already in place [because] data capture and modeling is more developed.” Technology use was generally more common on medium and large expansion projects, in part due to its high initial investment cost.

A subsequent research project (O’Connor and Won 2001) conducted a detailed analysis of the level of information/automation metrics at the work function level; the 15 construction management work functions and 11 construction engineering work functions are relevant to this dissertation. The work functions with the highest degree of technology use on industrial projects were “Develop detailed construction schedule,” “Update cost forecast,” and “Track field progress & labor workhour charges.” The work functions with the lowest degree of technology use were “Communicate changes to field,” “Communicate status of change orders to field,” and “Communicate Request for Information & responses.” The impact of these low-technology functions was clarified by O’Connor and Yang (2002), who addressed the relationship between technology usage and project success measures. They concluded, “Project schedule success or failure is particularly leveraged with technology usage or lack thereof for” six work functions, which included communicating and responding to Requests for Information (RFIs) and
updating as-built drawings. The Tier II concept of IT utilization includes these low-
technology functions.

Project collaboration software is one method of achieving integrated information
technology at the project level. Unger (2003) reported, “By late 2001, 40 percent of
general contractors had tried project collaboration software, according to the
Construction Financial Management Association’s ‘2002 Information Technology
Survey for the Construction Industry.’”

Unger (2002) predicted that client-server based systems will soon be replaced by
internet-based systems, whose benefits include supply chain integration, real-time
collaboration, more predictable cost, and efficiency. An Associated General Contractors
(AGC) survey indicated significant use of the internet for project services (AGC 2002).
Of more than 2,500 respondents,

- 43 percent used the internet for online services. Of those using the
  internet, 63 percent used it for plan distribution and 52 percent used it for
  online collaboration.
- 28 percent used an Application Service Provider (ASP) such as
  Primavera’s PrimeContract®, Constructware™, Meridian’s ProjectTalk,
  etc.
- 64 percent were interested in learning more about online construction
  services, including project management and online plans.

These survey responses indicate the extent to which the internet is being used by
the construction industry, and the interest in increasing its use. The Tier II strategy
addresses the use of IT for many of these issues, including plans, communication, project
management functions, and RFIs.
The adoption and implementation of integrated information technology is clearly a long-term strategy – a 2001 Constructware™ client survey found a correlation between users responding that Constructware™ gave them a competitive advantage and the length of time they had used the software – approximately 30 percent after one year, 50 percent after two years, and more than 75 percent after three years.

The benefits of information technology at the level of major project participants (e.g., owner, designer, contractor) are well-documented. The Fails Management Institute stated, “The advent of collaboration tools has helped owners and their suppliers cut time and cost out of the delivery process by making sure the right people have the right information at the right time to make the right decisions.” (FMI 2003). Tier II seeks to take integrated, real-time communication into the field, and put it directly in the hands of field supervisors and Tier II JCWs, decreasing the cost of communication through more efficient information exchange.

Coble, Qu, and Sun (1998) addressed the specific needs of foremen regarding computers. They mention that previous studies indicated reluctance on the part of foremen to learn to use computers because of the perception of the amount of training required. Although this may still be a widely-held opinion, the CCIS baseline data indicate that this is no longer a significant barrier (Brandenburg 2004). Coble, Qu, and Sun emphasized that “[t]he need for construction foremen to be able to access and capture job-related information is extremely critical.” In the Tier II strategy, this also applies to Tier II JCWs.

Alemany (1999) surveyed 179 foremen working at 6 companies using foreman task-level automation for administrative tasks. A majority (57 percent) reported using a computer at work. Of these, 92 percent used computers in the office and 14 percent used computers in the field. Foremen used the computers for short interval scheduling, time
keeping, and ordering equipment, tools and materials. Foremen who used computers spent an average of 14 fewer minutes per day at work, and 77 percent believed that it saved their companies money. The most significant finding was that the foremen who used computers reported spending almost 1 additional hour per day in direct supervision of their crews.

Wireless communication is the only feasible approach to putting computers in Tier II JCWs’ hands at the work face. This concept was also addressed by Coble, Qu, and Sun (1998). Researchers at Carnegie Mellon University and Frontier Systems, Inc. developed a wearable computer with a voice-activated command system and a small hardhat-mounted LCD screen in the mid-1990s, but it was never marketed (Quinn 1993, Pasquale 2004). Sawyer (2003) discussed the increased availability, and the benefits and challenges of implementing wireless data exchanges between field personnel, and described different commercial systems available for wireless management of daily reports, standard forms, time cards and quantities, change orders, and RFIs.

CCIS conducted research related to information technology utilization in a Tier II context. Balli (2002) estimated the impact of handheld computers and wireless networks on five field activity processes – punchlisting, material tracking, locating Material Safety Data Sheet (MSDS) information, inquiring about work in place, and obtaining project drawings. She modified the processes to reflect the impact of Tier II computer use, and assumed durations for the “as is” and “modified” processes. She estimated that the use of wireless handheld computers could reduce task times by 16 percent to 71 percent, and delay times (gaps in the process) by 51 percent to 95 percent. The key finding was the significant decrease in the delays or gaps between the steps of the processes, due to the foreman’s or Tier II JCW’s ability to directly access information instead of requesting it from someone else, or leaving the work face to retrieve it themselves.
Saidi (2002) demonstrated through experimentation the benefits of using handheld computers for pipe quantity tracking. He documented the performance problems experienced with the particular handheld computer used in the experiment, which included an awkward text input interface, only one expansion slot, the unreliability of wireless network connection due to weak signals and/or interference, low camera resolution, and low backup battery life.

Much of the research presented in this section includes the identification of needs and/or recommendations for areas in which information technology could be most valuable at the foreman/Tier II JCW level. In terms of general characteristics, O’Connor and Won (2002) identified the most technology-demanding characteristics: work functions that involve a significant amount of data updating, iterations, and revisions; repetitive activities; and those for which the accuracy of the data is crucial to success. Saidi (2002) identified characteristics of tasks for which handheld computers are well-suited, including access to large amounts of information, viewing a small part of a document, entry of simplified data on checklists or standard forms, and the instant transfer of small amounts of information. Saidi (2002) also identified characteristics of tasks for which handheld computers are not well-suited, including those requiring significant processing power, a constant network connection, or a considerable amount of manual data entry; viewing a large part of a document; and activities performed mostly in conditions that would interfere with the ability to view information on the computer screen.

In terms of specifics, the following is a consolidated list of recommended activities suitable for field-level handheld computers. It is presented in no particular priority and it is not comprehensive, but it emphasizes the areas identified in Tier II: Locating and ordering tools, viewing updated drawings and 3-D CAD visualizations,
reviewing specifications, managing RFIs, communicating design changes to field personnel, creating as-built records, managing material submittals, locating and ordering materials, managing equipment, managing timesheets and payroll, and updating performance monitoring information (e.g., daily reports, safety checklists and reports, quality checklists and reports, initiating requests for inspection, cost management, schedule management, progress and productivity reporting, and visually recording jobsite progress) (Coble, Qu, and Sun 1998; Alemany 1999; Haas, et al. 2000a; O’Connor and Won 2002; Saidi 2002).

2.4.4 Craft Utilization

Burleson (1997) defined multiskilling as “a labor utilization strategy where workers possess a range of skills appropriate for more than one work process and are used flexibly on a project or within an organization.”

CCIS completed a number of studies on multiskilling in recent years; those most applicable to the scope of this dissertation are briefly summarized.

Burleson (1997) quantified the impact of four different multiskilling strategies on project manpower requirements and individual employment duration by applying the strategies to an example project and comparing the results to a “baseline” (single-skill) condition. She evaluated the following multiskilling strategies: (1) dual-skilled individuals, (2) four construction trade classifications, (3) four construction trade classifications with all helpers in one general “pool,” and (4) a theoretical maximum case of one construction trade. She concluded that multiskilling can result in increased individual employment duration, increased productivity, decreased project labor costs, and decreased overall project costs.

Carley (1999) surveyed more than 1,100 craft employees of 12 companies that implement a multiskilled strategy. The survey revealed that approximately 70 percent
had worked outside their trade, approximately 80 percent were interested in learning additional skills within their primary trade (multiskilling) and approximately 60 percent were interested in learning additional trades (multicrafting). The workers’ preferred method of improving their skills was on-the-job training (36 percent), followed by company-provided training (27 percent), union-provided training (21 percent), and community college (8 percent). Workers’ perceived benefits of multiskilling included the ability to work more hours at a higher wage rate, do more challenging work, stay on a project longer, and stay with a company longer.

The metrics establish the minimum extent of multiskilling anticipated in the Tier II strategy. There are maximum practical limits as well. Gomar’s analysis indicated that “the benefits of multiskilling are marginal beyond approximately a 20% concentration of multiskilled workers in a project workforce.” (Gomar, Haas, and Morton 2002). Carmichael and MacLeod (1993) studied multiskilling in Japanese manufacturing firms. They stated that “firms will not in general want all of their workers to be multiskilled.” They described the workforce in terms of single-skilled “temporary” workers and multiskilled “permanent” workers. Carmichael and MacLeod pointed out an important difference between these two groups, in that “[w]ages of permanent workers are ‘attached to the worker’ rather than to the job, while those of temporary workers reflect the job they are in.” Finally, in large part because of their wages and status, “[m]ultiskilled workers exhibit lower turnover levels than those with single skills.”

2.4.5 Organization

The Tier II Organization index consists of two interrelated elements: communication and high performance work place. The goal of communication in Tier II includes frequent and proactive communication throughout the organization. The importance of effective communication has long been acknowledged in qualitative terms.
CICE identified the impact of communication on productivity and the need for communication training at the supervisory level. Thomas (1996) determined a strong statistical correlation between “perceptions of effective communications and project success” from a sample of 608 questionnaires and 72 construction projects. Effective project communication is essential not only to the organization component of Tier II, but also to the IT component, which envisions Tier II JCWs having access to project information that is not normally shared with foremen or the journey-level workforce.

Communication is also a significant factor in the second element of the Organization component, which generally defines the characteristics of a “high performance work place” and “high performance work teams.” The literature includes a number of different approaches to and definitions for these terms, and some of these are discussed briefly. Because the theoretical formation of Tier II was significantly influenced by Ray Marshall’s work, we start with the attributes of and indicators present in high performance work organizations. Those most closely associated with the Tier II strategy include (CSHR 1994):

- Flexibility through multiskilling.
- Decentralized decision-making achieved by shifting decision-making toward front-line workers, and encouraging employee involvement in determining the work process, administration and scheduling, and strategic planning.
- The effective use of resources achieved through the development of “portable general skills such as interpersonal, problem solving, and consensual decision-making skills” and a “[s]ignificant increase in training expenditure on non-managerial staff.”
A positive rewards structure including higher than average wages and pay based on individual merit and team performance.

An “independent source of employee voice” evidenced by extensive employee involvement and resulting in a reduced absenteeism and turnover.

Bailey, Berg, and Sandy (2001) studied high performance work systems in the steel, apparel, and medical electronics and imaging industries. They observed three major characteristics: “a work organization that provides employees with the opportunity to participate in decisions, incentives that encourage employee participation, and human resource practices that ensure an appropriately skilled work force…Organizing the work process so that non-managerial employees have the opportunity to contribute discretionary effort is the central feature of a high-performance work system (HPWS).”

High performance work teams can exist in a number of different forms. The Ray Marshall Center for the Study of Human Resources describes these as supervised, self-directed, and autonomous teams (CSHR 1994). Early Tier II documents posited that “[t]he Tier II Work Team may be defined along the lines of a self-managed work team geared toward the construction industry” (Haas, et al. 2002a).

Emery and Trist (1960) studied the effect of “conventional” and “composite” social systems in the coal mining industry. The conventional system was based on individual miners completing single-skill tasks, and the composite system was based on more of a team approach, similar to the team and multiskilling concepts in Tier II. The “composite systems consistently showed a superiority over the conventional in terms of production and costs.” The composite systems also experienced significantly less absenteeism as summarized in Table 2.3.
Table 2.3: Absenteeism for Different Coal Mining Work Organizations\(^2\)

<table>
<thead>
<tr>
<th>Absenteeism due to:</th>
<th>Conventional System</th>
<th>Composite System</th>
</tr>
</thead>
<tbody>
<tr>
<td>No reason</td>
<td>4.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Accidents</td>
<td>6.8%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Sickness or other</td>
<td>8.9%</td>
<td>4.6%</td>
</tr>
<tr>
<td><strong>Total Absenteeism</strong></td>
<td><strong>20.0%</strong></td>
<td><strong>8.2%</strong></td>
</tr>
</tbody>
</table>

Emery and Trist made important conclusions regarding the more mutually supportive relationships and the flexibility inherent in the multiskilled teams to meet changing task requirements. They concluded that the superiority was based on “more adequate coping [by] the composite system with the task requirements…It is difficult to meet variable task requirements with any organization built on a rigid division of labour.” Construction involves rapidly changing conditions similar to those described in the Emery and Trist study; therefore, it is reasonable to extend their basic conclusions to construction.

Additional project-level benefits of a high performance work system include improved productivity and reduced costs, in large part because “planning and problem-solving on the shop floor saves time and minimizes disruptions by avoiding the need to summon supervisors or specialists, or to send problems up and decisions down a hierarchical line of authority.” (Bailey, Berg, and Sandy 2001). Cappelli and Neumark (2001) found some evidence of improving productivity and decreasing unit labor costs in manufacturing firms, but did not find statistical support to conclude that the increase in productivity offset the increased wages paid to higher skilled workers.

\(^2\) Adapted from Emery and Trist (1960).
Pil and MacDuffie (1996) studied high performance work practices used by automobile manufacturers. They deliberately used the term “high-involvement work practices” to describe those that cannot be statistically linked to high performance. They discovered that using “high-involvement [human resource] practices and work systems…together results in greater performance than the sum of the performance resulting from using each practice separately.”

One of the goals of Tier II is to increase individual wages (Borcherding, et al. 2001). Cappelli and Neumark (2001), based on their longitudinal study of the effects of high performance work practices in manufacturing firms, reported statistical support for the conclusion that high performance practices increased employee compensation. Bailey, Berg, and Sandy (2001) recommended the use of higher wages (based on the higher skills requirement of the position) rather than profit sharing, because profit is sometimes impacted by factors outside labor’s control. They described two perspectives: pay-for-performance, where “workers earn more because they have produced more” and efficiency wages, where “[e]mployers may pay higher wages in general in the expectation that workers will reciprocate with greater productivity.”

Training is important, and also impacts individual compensation. Bailey, Berg, and Sandy (2001) pointed out that “workers in a [high-performance work system] carry out a greater number of technical tasks and are responsible for broader supervisory functions than are workers in a traditional production system. Furthermore … these workers receive more formal and informal training. All of these factors should result in higher earnings for workers in high-performance work systems.” Emery and Trist (1960) stated that “[t]he critical prerequisites for a [team] system are an adequate supply of the required special skills among members of the group and conditions for developing an appropriate system of roles.” They concluded that the composite system (work teams)
should not necessarily be applied in all areas, but should be applied selectively based on careful analysis of the task requirements, and somewhat based on trial and error. They recommended structuring these teams in natural task groupings (e.g., geographical areas in a construction context) – “…clearly distinct areas of command which contain within themselves a relatively independent set of work roles together with the skills necessary to govern their task boundaries…proved to be inherently stable and self-correcting.”

Pil and MacDuffie (1996) emphasized the long-term perspective required to implement this type of fundamental organizational change. Although such a change requires long-term investment, it potentially yields long-term benefits that eventually exceed those of more incremental or “evolutionary” changes. They warned that large changes in an organization’s fundamental practices can actually decrease performance over the short term, and they acknowledged that in the current business environment “superior practices that do not yield immediate results face a high risk of not being retained.”

The uncertainty of the change at the individual level is an important factor to manage. Pil and MacDuffie (1996) identified the uncertainty faced by both labor and management: “They have to learn new roles, new ways of interacting, and develop a new degree of trust in the new system and one another. The less experience employees have had with the current system, the easier the change may be, because their expectations about the work environment would be less fixed, and current routines would be less ingrained.” Marshall required an effective industrial relations system (1992) or other “independent source of employee voice” (CSHR 1994), due to the mutual dependence and adversity inherent in the relationship between labor and management. “Workers and managers often clash over inherent conflicts in the components of a high-performance system. Management typically wants to restrain wages, for example, whereas workers
want to increase them. Workers value job security, while management stresses ‘flexibility,’ a tool that can threaten earnings, inhibit work rules to protect safety and health, and lead to ‘outsourcing’ and the use of temporary contingent workers.”

“Workers are unlikely to go all out to improve productivity and quality unless they have an independent source of power to protect their interests in the process.” (Marshall 1996). This independent source does not necessarily have to be a union, but can be any entity that provides enough “security” for workers’ interests to make the implementation possible. Marshall (1996) specifically addressed the implementation of high performance concepts in a union environment: “the nature of the relationship between unions and management therefore is an important determinant of whether unionized firms can be high-performance organizations.” Pil and MacDuffie (1996) agreed: “the successful implementation of high-involvement work practices requires mutual understanding that not only are employees committed to the organization they work for, but that the organization shows commitment to them in return.”

Chapman and Gerson (1999) published the first documented case studies of the use of high performance work teams on a construction project. Although the article expressly made only preliminary assessments, it documented valuable lessons learned, which included the prerequisite for visible management support, and the recommendation that the teams “contain multitalented people willing to do whatever it takes to get the job done,” and the fact that employees developed “a feeling of ownership in their work.” The first implementation was small (30 workers), but achieved outstanding results in terms of project safety, cost, schedule, absenteeism, and turnover.

A second, slightly larger attempt by the same contractor included “more decision-making and some multicraft responsibilities.” Key components of this second attempt included management support, an operating implementation model, people, rewards,
training, assessing team development, communication, measuring results, and process improvement. The teams were structured as “led teams” as opposed to “self-directed teams.” They were composed of people from different crafts and different skill levels to “encourage problem solving and innovation and share in decision making.” The project was managed with a geographical area concept, and the exact makeup of each team was determined based on the requirements of the work in that area; one team was “single-craft” because that best suited the requirements of the work in its area. Teams were provided greater than typical access to cost reports and other project documentation, and were responsible for their own results. Important findings included that team leadership responsibilities are different from typical foreman responsibilities, and team membership responsibilities are different than typical crew member responsibilities. “To be successful, the team leader must hand off some of those day-to-day responsibilities in order to have the time needed to plan and facilitate.” The best-performing team exhibited “information sharing, shared decision making, use of multicraft, and empowerment.” The project achieved better teamwork between journey-level craft workers and helpers within crews, shared decision making, more coordination between designers and team leaders/journey-level craft workers, and most importantly, a satisfied owner (Chapman and Gerson 1999).

2.5 Related Industry Efforts

The construction industry has developed a number of programs to address the skilled labor shortage. At the highest level, these efforts can be described as increasing the supply of skilled labor, decreasing the demand for skilled labor, or a combination of the two.
2.5.1 Efforts to Increase Supply

Industry efforts to increase the supply of skilled construction labor are primarily related to recruiting, retention, and training. CII’s “Attract/Maintain Skilled Work Force Research Team” studied recruiting, retention, and training issues extensively, and reported their findings in two reports (CII 1999, CII 2000). The team gathered data from more than 1,200 individuals and 21 contractors. Sixty percent of the responding contractors had formal recruiting and hiring programs specifically to hire qualified construction workers, and 40 percent had formal retention programs.

The CII team reported that 70 percent of the individual respondents did not want their children to work in construction. Discussions with craft workers during the CCIS data collection in 2002 qualitatively indicated that this number has increased. CII identified these major reasons for retention problems from the individuals’ responses: (1) “Poor pay and benefits,” (2) “Need for a permanent job,” (3) “Poor safety,” (4) “Poor treatment,” and (5) “Poor working conditions.” (CII 2000).

From the companies’ responses, CII identified these key recruitment issues: (1) “Recruit at trade schools, high schools, and community colleges,” (2) “Pursue reduction in force (RIF) employees to keep them working,” (3) “Work with other contractors for hiring,” (4) “Recruit outside of project locations,” and (5) “Have formal written tests and performance tests as a mechanism to hire qualified workers” and these key retention issues: (1) “conduct a needs assessment to train workers on a continuous basis,” (2) “Conduct supervisory human relations training,” (3) “Tie documented wage progression to skills,” (4) “Give long-term preferential treatment to tenured employees,” (5) “Inform employees of project progression,” and (6) “Emphasize the community side of construction.” (CII 2000).
Pay is a prominent issue in any discussion of the skilled labor shortage. The difference between construction and manufacturing hourly wage rates in the U.S. grew steadily until 1972, as indicated in Figure 2.8. Over the last 30 years, that difference has decreased drastically from $8.14 per hour to $3.21 per hour\(^3\). Some hypothesize that this smaller difference in the hourly wage rate has combined with the generally more comfortable work environments, more regular employment opportunities, and more comprehensive benefit packages offered by the manufacturing industry to create a net loss of construction workers to manufacturing jobs (CII 2000).

![Difference in Real Construction and Manufacturing Wages, 1953-2003](attachment:Figure_2.8.png)

Figure 2.8: Difference in Real Construction and Manufacturing Wages, 1953-2003\(^4\)

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\(^3\) Real wages, in 2003 dollars. Data from [www.bls.gov](http://www.bls.gov).

\(^4\) Data from [www.bls.gov](http://www.bls.gov).
The NCCER Industry Task Force addressed the wage issue directly. “We have to begin looking at money. It is not the total answer, but it is a beginning,” said Frank Yancey, senior vice president of construction/maintenance at Kellogg Brown & Root, Houston…. ‘We are going to raise our wages and we are not going to take a survey,’ said [Ted Kennedy, chairman of BE&K, Inc.]. ‘I have a belief that wages are way too low. I think [the hike] will attract the higher skilled and trained people. We will go after them with a vengeance.’” (Krizan 2000).

One contractor interviewed for this study uses the efficiency wage approach and offers $1 to $2 per hour more to recruit highly-skilled craft workers who meet strict qualifications (some company-specific training in addition to NCCER Certified Plus or equivalent). This approach is successful as a recruiting tool, and the contractor’s project performance data show that the increase in productivity more than offsets the additional wage cost. However, the contractor only uses this approach on lump sum work, because owners will not approve the added cost on reimbursable projects.

A 1997 Business Roundtable white paper documented the use of a number of financial incentives in an effort to attract skilled construction workers, including overtime, special recruiting, special wage rates, and bonuses (BRT 1997). A number of these incentives were reported in the CURT (2001) survey, as were benefits, including holiday pay, relocation assistance, per diem, and referral pay. It is interesting to note that 64 percent of incentive packages were valued at more than 10 percent of the worker’s gross pay. More than one-third of the respondents “cited extended workweeks and guaranteed overtime as the most effective incentive.” (CURT 2001). It is important to recognize that while these incentives increase the individual’s take-home pay, they have minimal impact on the hourly wage. It could also be described as a somewhat short-
sighted approach, in that the negative impacts on safety, productivity, and project cost due to extended work weeks is well documented (BRT 1980, CURT 2004a).

The Associated Builders and Contractors Strategic Plan Report (2000) emphasized a goal to “position construction as an attractive career.” Respondents to the CURT (2001) survey reported additional recruiting efforts that included recruiting in high schools, trade schools, vocational schools, and rural areas, as well as targeted recruiting of Hispanics and women.

Companies and industry organizations have created programs that combine training with “long-term” recruiting. These efforts include school to career programs (Barkett 2003, Clarkson 2003, Idaho AGC 2003), high school construction technology programs (Logue 2004), and prison vocational programs (NCCER 2003d). The first construction charter school in the country opened in 2001 in St. Louis (Eivins 2004). Construction career academies, which operate within existing high schools, have been established in Chattanooga, San Antonio, and San Diego (Tudor 2004, McMurray 2004, Morris 2004). The BE&K School of Industrial Construction provides 15 hours per week of construction training for high school students, and BE&K guarantees those who graduate from the program full-time employment (CIF 2001). The Helmets to Hardhats program recruits veterans separating from the military into union apprenticeship programs (H2H 2004). Both the BE&K School of Industrial Construction and Helmets to Hardhats won 2003 CURT Workforce Development Awards (CURT 2003).

Technical skill standards for the industry have historically been based on joint labor-management apprenticeship programs. Skill standards became a concern because of the growth of and new training efforts within the non-union sector. Srour, et al. (2004) described the benefits of skill standards and the current state of skill standards in the U.S. construction industry. The NCCER Contren® training curriculum discussed previously
meets minimum Office of Apprenticeship Training, Employer and Labor Services (OATELS) requirements for classroom training and has essentially become the standard curriculum throughout the non-union industrial construction sector. NCCER developed the National Registry, a database containing individual training records, to enhance the portability of its training. NCCER offers task training, apprenticeship training, upgrade training required to achieve “Certified (Written)” status, cross-training, multiskill training, safety training, and management training.

Union sector joint labor-management apprenticeship programs are funded through training fees paid on a work-hour basis. The non-union sector has struggled with finding consistent ways to fund training. NCCER established the voluntary National Training Service Agreement (NTSA), through which a participating contractor contributes 15¢ per labor hour that NCCER holds in a training account. The contractor then charges training costs against its account. The NTSA provides a convenient method to account for and document training expenditures (NTSA 2004).

NCCER training courses are frequently offered by local ABC chapters through local community colleges and off-site contractor training forums. For instance, in September 2003, the Greater Houston chapter of ABC Construction & Maintenance Education Foundation (CMEF) reported more than 800 students enrolled in 4 colleges and 16 off-site contractor forums. They also reported the implementation of new computer-based skills assessment programs at various locations (Pappas 2003). AGC publicized its chapters’ workforce training programs in the March 2004 issue of Constructor (AGC 2004).

A new approach to craft training was recently developed by Compass Educational Holdings (CEH) (NCCER 2003b). To counter the high dropout rates of traditional craft
training programs, CEH combines recruiting, financing, and education to provide skilled construction workers to the industry. Individuals pay for their own training, and CEH assists them with obtaining student loans as needed. The training consists of two components. The first component is eight hours per day for four weeks, and includes training in the areas of safety, basic construction skills, soft skills (e.g., communication, teamwork) and the Contren® Level One curriculum for their craft. The second component is an eight month externship during which the individual works for a local contractor during the week while completing laboratory requirements and attending classes on Saturdays. The full certificate program concentrates four years of typical apprenticeship classroom training into nine months. The result of the accelerated training and the personal investment is that the vast majority of students complete the training. Programs include electrical, carpentry, plumbing, pipe fitting, and HVAC, and cost between $10,000 and $13,000, which is comparable to the cost of some joint labor/management apprenticeship programs in the Houston area.

The Construction Industry Network for Essential Skills Training in Alberta, Canada (CINESTA) is a group of six organizations that tailor trade-focused essential skills training programs for construction clients. The six “essential skills” are reading and reading comprehension, writing, math, document use skills, oral communication skills, and English as a Second Language (ESL). Three of the programs are described briefly (COAA 2004):

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5 A study of more than 81,000 individuals entering construction apprenticeship programs between 1989 and 1991 found completion rates of only 41 percent in joint labor-management programs and 25 percent in non-union programs as of November 1995. The dropout rates were 37 percent and 54 percent, respectively, and 21 percent of apprentices in each type of program were still active in the programs. (Bilginsoy 1998).

6 The externships are offered through Decker College of Business Technology, www.deckercollege.com.
• Calgary Catholic Immigration Services integrates “essential skills instruction with technical theory, shop training and work placement” into its 22-week course, at no cost to the participant.

• Mennonite Central Committee Employment Development’s 21-week Trades Entry Program (also at no cost to the participant) consists of 10 weeks of classroom instruction in core skills – including English, math, and science – and “life skills” – including working in teams, developing positive attitudes, responsibility, building relationships and conflict resolution; 6 weeks of hands-on technical and safety training; and 5 weeks of work experience.

• NorQuest College’s 27-week “ESL Trades Program” targets immigrants and boasts a 90 percent job placement rate. The course costs $1790.

Some contractors have created special recognition programs to improve the retention of key personnel. Common criteria for selection include certain skill levels, active participation in training, and attendance history. Selection decisions are made by evaluation boards. Benefits to the individual can include a higher wage rate, insurance, vacation/bonus pay, and relocation pay to a subsequent project. One contractor guarantees its selected personnel full-time employment.

The Houston Business Roundtable (HBR) created a Construction Workforce Development Award in 2002 to encourage contractors to invest in their human capital. Owners nominate contractors to the HBR award committee, which then audits the nominees’ workforce development programs. Audited items include training statistics as well as success measures such as productivity and absenteeism rates.
2.5.2 Efforts to Decrease Demand

These efforts are primarily designed to utilize the current workforce more effectively, which can reduce, to an extent, the need for additional craft workers.

Contractors have changed work methods to increase productivity through greater use of automation, prefabrication, and modularization (CII 1990; CII 1992a; Haas, et al. 2000b). Contractors have also implemented productivity improvement programs and structured short-interval planning techniques such as the Last Planner®.

Multiskilling and multicrafting in the context of Tier II can reduce the demand for labor through (1) longer individual employment durations and (2) greater flexibility in worker assignments, which can result in less unproductive time and more variety of work for the individual (Tucker, et al. 1999). Multiskilling cannot totally compensate for the skilled labor shortage, however; additional actions are required (Haas, et al. 1999b).

One owner reduced the demand for skilled labor by redesigning a project during construction to eliminate the need for masons because none were available (CURT 2001). This surely was not the ideal course of action, as it must have proven expensive, but it was apparently the best of the alternatives.

2.6 Strategic Management of Human Resources

Ray Marshall underscored the importance of human capital as “the main source of improvements in productivity throughout history.” Human capital requires development, however. Although the correlation between skills and productivity is becoming more identifiable, and despite the fact that “U.S. companies spend between $30 billion and $40 billion on formal education and training activities, very few companies actually provide education and training, and very little is spent on frontline workers.” (Marshall 1994). The Tier II strategy focuses on the development of construction’s frontline workers.
2.6.1 **Construction Industry Human Capital**

“Well-trained workers…are part of the total asset base of any construction company – and every bit as important as physical or financial assets.” (COAA 2004). Considering the effect of the current skilled labor shortage, human capital becomes even more valuable as a competitive advantage for those who manage it well.

Picard and Seay (1996) stated that “The role of labor is changing from just a means to get work done to a valued input on constructability and work process.” Construction labor is too frequently viewed as a commodity. When all craft workers are considered identical, they are assumed to produce the same amount of work per labor hour, and so the smart purchasing decision becomes simply to buy the cheapest hourly rate. In reality, nothing could be further from the truth. Productivity is influenced as much by the effective flow of resources to the crews (short-interval planning and management) as by any other factor (Evans 1999; Pappas, Tucker, and Borcherding 2003; CURT 2004a). Construction funds are more wisely invested when owners concentrate on total project cost rather than the craft worker’s hourly wage rate. To date, most contractors found it difficult to quantify their productivity; therefore, owners have focused on the only piece of hard data available to them, which is the hourly wage rate.

The problem is not only with the purchasers of construction, however. Contractors frequently claim that their employees are what sets them apart from their competition, and certainly, in a labor-intensive industry such as construction, this is appropriate. Why then do contractors typically invest so little in training their employees (CPWR 2002, Brandenburg 2004)?

There is a concern among owners and contractors that training investments in personnel will be lost as individuals move on to work for competitors. This is not new: “Why train employees who may be working for the competition tomorrow? The cyclical
nature of … the industry makes this a very real possibility. But perhaps this is a self-fulfilling prophecy. If nobody is willing to take the risk, no one has a superior work force…” (CII 1996b). This concern is apparently somewhat unique to the construction industry, however – on a nationwide basis, “[l]ess than 10 percent [of employers] reported that the cost of formal training was too high or that they were unwilling to provide formal training due to a fear of losing trained employees to other employers.” (BLS 2004d). The reality is that many highly-skilled craft workers rotate among a small number of contractors, using their skills and the free market to their advantage, but the end result is that they consistently return to the same employers. This situation lends itself to the possibility of companies cooperating to implement a regional approach to workforce development. Another approach to this problem will be presented in Chapter Four.

2.6.2 Return on Investment of Human Capital Development

Accurately evaluating the return on human capital investment is difficult. The Business Roundtable surveyed 130 contractors, of whom only 21 percent “indicated that they conduct studies to evaluate the effectiveness of their supervisory training programs.” (BRT 1982b). The report acknowledged that “[a]ny estimate of savings to U.S. industry accruing from construction supervisory training would be subjective. However, case histories of major contractors have consistently indicated substantial savings. In every case, the savings resulting from improved productivity were several times the cost of the training. Other probable benefits to the owner’s project include better schedules, improved safety and quality, and reduced turnover and absenteeism. Experience shows that owners who support contractors’ training programs can reasonably expect a return on their investment of at least 3 to 1.” (BRT 1982b).
Glover, et al. (1999) addressed challenges to measuring Return on Investment (ROI) in the construction industry. These included the difficulty in identifying and quantifying the benefits of training, the difficulty in isolating the impacts of training, the fact that benefits often accrue slowly, and cultural resistance to measuring the ROI of training. Glover described the common business approach of a benefit-cost analysis, which is “transparent, practical, and relatively easy to implement…However, it relies heavily on estimation by managers, which lessens empirical rigor.”

Jack Phillips, a world-renowned expert on measurement and evaluation, reported that although some corporations require evaluation plans to be submitted with training proposals, the vast majority do not have effective methods in place to evaluate the benefits of their employee training programs (Phillips 1991). He described two different classes of data:

“Hard data are:

- Easy to measure and quantify.
- Relatively easy to assign dollar values.
- Objectively based.
- A common measure of organizational performance.
- Very credible in the eyes of management.”

“Soft data are:

- Difficult to measure or quantify directly.
- Difficult to assign dollar values.
- Subjectively based in many cases.
- Less credible as a performance measurement.
- Usually behaviorally oriented.”
Hard data are frequently summarized in broad categories of output (e.g., quantity in place, unit rates, productivity), quality (e.g., rework), cost, and time (e.g., overtime, efficiency, delays). Soft data are frequently summarized in broad categories of work habits (e.g., absenteeism, tardiness), new skills (e.g., problem solving, decision making), work climate (e.g., turnover), individual development/advancement (e.g., pay increases, promotions), feelings/attitudes (e.g., loyalty, confidence, reactions), and initiative (e.g., training, studying, homework).

With respect to quantifying the benefits of construction training, hard data are normally available in terms of value of increased output, value of cost savings, value of time savings, penalty avoidance, opportunity for profit (including bonuses), reduced training time, value of improved quality, scrap/waste, rework, customer/client dissatisfaction, inspection and quality control, and employee morale. Soft data can be developed from existing data or historical costs, expert opinion, participant estimates, or management estimates. General guidelines are to quantify what can be quantified, and then estimate what can be estimated. Benefits that cannot be quantified or estimated should be documented for qualitative consideration.

Phillips (1991) presented different types of return calculations; some of this discussion was paralleled by Glover, et al. (1999). Return on Investment (ROI) calculations are normally best-suited for situations where benefits can be clearly identified. The degree of confidence in the ROI calculation corresponds to the degree of confidence in the identification and quantification of benefits. A benefit-cost (B/C) ratio is used more frequently in human resource development analyses because ROI calculations typically involve standard accounting procedures, while a B/C ratio does not. Phillips recommended always reporting costs and benefits together, and cautioned against projecting more precision into the analysis than is appropriate for the situation. It is
sometimes most appropriate to present benefits and costs in ranges, as opposed to specific figures.

2.7 ROLES IN ORGANIZATIONAL CHANGE

Organizations implementing a Tier II approach must take a long-term view of the process and resist the tendency to demand immediate returns. Tier II is a comprehensive approach to a very complex problem. Research and experience show that significant organizational changes often result in a decrease in performance for a time, due to the new skills required, the new approach to the work, and other factors (Pil and MacDuffie 1996). It is essential to set reasonable expectations, develop a method to evaluate progress, and fully support the effort to change. It is also important to effectively communicate expectations to employees – for example, what is the expected new or different behavior after a training program? When expectations do not change or are not effectively communicated, the employee may not change his behavior and the value of the training may be lost (Phillips 1991).

The following subsections combine recommendations for various parties that have been issued by a number of organizations, including The Business Roundtable, Construction Industry Institute, Construction Users Roundtable, Houston Business Roundtable, and the Ray Marshall Center for the Study of Human Resources.

2.7.1 Owners and Local User Councils

Owners and Local User Councils must take a lead position in the implementation of Tier II, similar to the role they played in the improvement of construction safety in the 1990s. “Owners should recognize that supervisory training is cost effective and thus support contractors’ training efforts.” (BRT 1982b). Tier II JCWs are included in some of this supervisory training.
Owners must choose to ask for workforce development plans in proposals, structure contracts to support workforce development, establish training standards, and do business only with contractors who invest in their workforce. Owners should address training costs in the contract to establish a clear understanding with contractors regarding who will pay these costs, how, and when.

Owners and Local User Councils must work with contractors, unions, and other organizations to fund training; support initiatives for recruitment, training, and retention; and work with contractors to develop evaluation methods to assess program effectiveness. Facility owners may generate significant long term benefits by cooperating with other entities to pursue a regional approach to workforce development. Owners and Local User Councils can create and promote workforce development awards to recognize effective practices.

2.7.2 Contractors and Contractor Associations

Contractors and Contractor Associations must invest in, support, and push the implementation process in order to upgrade the skills of the construction workforce. This includes improving the construction industry image, recruitment, and retention, as well as making training a standard practice. Contractors must analyze specific training needs and invest training funds where they will provide the most impact. Contractors should develop career progression programs, consider a pay-for-skills approach to compensation, and work with owners to develop evaluation methods to assess program effectiveness.

2.7.3 Labor Organizations

Labor Organizations must assist with local and regional implementation plans, promote the development of training and apprenticeship programs and maximize their
utilization, expand training to include significant continuous skills upgrade training to journey-level craft workers, and work with owners and contractors to develop methods to assess the impacts of training and technology.

Labor organizations provide a vital link between labor and management. This role requires working with owners and contractors to meet workforce development goals and develop a more highly-skilled workforce while promoting the interests of individual workers.

### 2.7.4 Individual Craft Workers

Castañeda-Maza (2002) reported that the majority of the individuals surveyed were receptive to the principles embedded in the Tier II strategy: pursuing more technical training, including multiskilling and/or multicrafting; developing management, administrative, and computer skills; and working in an organizational structure that is less hierarchical and more empowering than the typical construction organization.

Individuals must capitalize on the development opportunities offered to them, and be willing to take a more proactive role in the management of the work at the crew level, where significant impacts can be made to improve project performance.

### 2.8 Summary

This chapter presented previous research and industry efforts relevant to the skilled labor shortage and the Tier II strategy. Three surveys by prominent organizations in the last eight years indicate the characteristics of the skilled labor shortage. It is widespread and impacts project success. Labor demand forecasts indicate that construction employment will increase 15 percent by 2012.
Industry efforts to counter the skilled labor shortage include innovative training, recruiting, and retention programs, importing foreign labor, and the increased use of automation, prefabrication, and technology.

Ray Marshall presented the concepts needed to pursue a high-wage/high-productivity strategy at a national economic level. Some of these principles apply to the Tier II strategy. The Tier II metrics include technical skills, management skills, information technology utilization, craft utilization, and organization.

The current state of the industry can be quantified in terms of Tier II by applying the Tier II metrics to the 770 foremen and journey-level craft workers and 20 projects in the CCIS workforce database.

Previous research on the components of Tier II indicates that the effective implementation of each of them can have positive impacts on projects and on individuals. For example, research on multiskilling and high performance work organizations both indicate that individuals benefit from more challenging work, higher pay, and more longevity with a company, and that projects benefit from lower labor costs and turnover.

The literature regarding IT utilization, multiskilling, and high performance work organizations all indicate the importance of flexibility in their application. These concepts must be applied in a customized manner that best suits the project and the personnel.

Determining the return on investment of human resource development is a challenging task. A benefit-cost ratio is the most appropriate measure for this purpose. The recommended practice is to quantify what can be quantified, estimate what can be reasonably estimated, and identify any additional benefits and costs for qualitative consideration.
Chapter 3: Methodology

The objectives of this dissertation are to determine the current status of the construction industry based on the Tier II metrics, provide quantitative guidance regarding the implementation of the Tier II strategy for an example project, and evaluate the expected benefits and costs of achieving an advanced level of Tier II implementation. Benefits and costs were both calculated using an hourly labor compensation cost of $27.17.

This methodology was developed with the guidance of six executive-level industry professionals at a meeting held in June 2003.

3.1 The Current Status of the Industry

The first objective was to quantify the current state of the industry using the Tier II metrics. The CCIS workforce database contains 888 individual records, collected from site visits to 20 construction and maintenance projects. The individuals completing the surveys were selected by their employers as members of key crafts for their respective projects. The 770 individual records from foremen and journey-level craft workers reasonably represent that segment of the United States industrial construction workforce for the purposes of this analysis.

The process adopted two major assumptions at this point: (1) that the CCIS workforce database provides a representative model of the skill levels of individuals (foremen and journey-level craft workers) in the U.S. industrial construction industry; and (2) that the Tier II metrics are accurate, in that more effective implementation of the Tier II strategy will generally result in better construction success as defined by the

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7 Average hourly wage rate of $19.02 plus $8.15 in benefits for all private industry construction workers, March 2004. [www.bls.gov/news.release/ecenr.nr0.htm](http://www.bls.gov/news.release/ecenr.nr0.htm).
Construction Phase Success Metric (Shields 2002). The development of the Tier II Baseline is illustrated in Figure 3.1:

**Figure 3.1:** Determining the Tier II Baseline

The Tier II Baseline indicates the current state of the industry based on the Tier II metrics. The average baseline project score was 3.8 on a scale of 1 to 10; the Tier II Baseline will be presented in greater detail in Chapters Four and Five.

3.2 **AN ADVANCED LEVEL OF IMPLEMENTATION**

The goal of “an advanced level of Tier II implementation” was somewhat arbitrarily defined as a score of 8 out of 10. This goal represents significant improvement over the current status of the industry (average = 3.8), yet acknowledges the fact that Tier II is an aggressive, future-oriented strategy, and therefore attaining a score of 10 is not currently feasible. It also considers the assumed diminishing returns as Tier II implementation approaches a “perfect 10.”

The difference between the Tier II Baseline and an advanced level of Tier II implementation represents the improvement required to achieve an overall score of 8 out of 10. This is illustrated in Figure 3.2.
An overall score of 8/10 can be achieved in numerous ways, based on different combinations of scores within the metrics. The combination of component scores presented in this dissertation was determined based on consideration of the metrics, the Tier II Baseline, and the feasibility (including cost and common barriers) of achieving a higher level of performance for each particular element on the example project.

For example, the assumption for individual technical skills was primarily based on the Tier II Baseline of 1 (median) to 1.5 (mean) certified skills – the logical initial goal is 2 skills per person.

The majority of the project benefits are expected to come from improved productivity. Research and experience show that this requires effective short-interval planning, which is a desired result of the Tier II individual management skills component. Planning and job management skills were maximized to improve short-interval planning, and because they are weighted heavily in the metrics. The goals for individual administrative and computer skills and the Project Information Technology Utilization elements were selected to support an effective short-interval planning system in general, and the planning and job management skills in particular.

The individual technical and management skills scores must combine to produce the required number of Tier II workers (foremen and JCWs). The amount of training
required to achieve this will maximize the continuous education and training element (Individual Technical Skills). This also provides the basis on which to calculate the percentage of Tier II workers (Project Technical Skills), crew mix (Project Craft Utilization), and use of multiskilled workers (Project Craft Utilization) elements, as well as the individual averages for the Project Technical Skills and Project Management Skills components.

The Project Organization elements are the most qualitative; these goals were selected to show moderate improvement over the Tier II Baseline.

Some adjustments and iterations of the individual element goals were required to produce the desired result of a Tier II Project Index score of 8/10.

3.3 A REFERENCE POINT FOR ANALYSIS

The workforce development aspects of Tier II can be implemented at the project level, the company level, and perhaps at some point in the future, a regional or industry level. The scope of this dissertation is the implementation of Tier II using a project as a reference point, and therefore it uses a hypothetical project workforce to illustrate the implementation. This hypothetical workforce was developed from the CII Model Plant, an example project developed in the mid-1980s primarily for purposes of estimating and productivity benchmarking. The original scope of work was an $85 million grassroots petrochemical project in Baytown, Texas. Material takeoff estimates were completed for approximately 76 percent of the project, or $65 million. The planned construction duration was 78 weeks, working a schedule of four 10-hour days per week. The labor assumptions included “Ample supply; Predominantly merit shop; Union labor follows Houston Ship Channel Agreement.” The average of five original direct labor construction estimates was approximately 510,000 work hours (CII 1986).
A number of contractors estimated labor resources for the Model Plant in 1996 for a multiskilling study. The direct labor estimate developed at that time was 484,280 work hours. In the “baseline” case of that study (a traditional single-trade approach), this translated to a workforce (foremen, tradesmen, and trade helpers) of 675 total hires, with a peak workforce of 306 (Burleson 1997).

The current value of the Model Plant, using the Engineering News Record Construction Cost Index, is $140 million, and the estimated portion of the project is $106 million. Therefore, in round numbers, the Model Plant in 2004 represents a $105 million grass roots petrochemical project, with a direct labor estimate of 485,000 work hours and a planned peak workforce of 306. Table 3.1 compares these Model Plant parameters to the mean and median construction project data from the CCIS workforce database.

<table>
<thead>
<tr>
<th>Project Parameter</th>
<th>CII Model Plant</th>
<th>CCIS Baseline Construction Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$105 MM</td>
<td>$122 MM</td>
</tr>
<tr>
<td>Direct Labor WHs</td>
<td>485,000</td>
<td>548,000</td>
</tr>
<tr>
<td>Peak Workforce</td>
<td>305</td>
<td>381</td>
</tr>
</tbody>
</table>

This comparison indicates that it is reasonable to apply the CCIS baseline workforce characteristics to the Model Plant as an example project or reference point for the purposes of this dissertation. The use of the Model Plant in this dissertation is consistent with CII’s vision that it could also be “used as a demonstration example for new concepts or ideas.” (CII 1986).

3.4 DETERMINE COSTS

The next step was to gather data from available sources – academic literature, as well as published and unpublished company data – regarding the implementation costs
for the various elements of the Tier II strategy. The author considered data from published sources, meetings and personal interviews with experienced industry professionals, and personal experience in order to estimate the implementation costs. The most accurate source of this information is likely the empirical data developed through the project experience of contractors and owners. Unfortunately for the purposes of academic research, these data are rarely published because they often represent proprietary information and a possible competitive advantage. The author identified multiple sources of unpublished company data in order to enhance the validity of the study. The voluntary participation of the individuals and companies listed in Appendix A was invaluable to the success of this study.

The author interviewed 12 management personnel from 8 construction organizations between September 2003 and July 2004. These interviews yielded valuable data regarding the type and extent of training currently offered to employees, as well as the costs and benefits of the training, and knowledgeable opinions regarding the implementation of Tier II. Each company collected, analyzed, and presented their internal data in different ways. The author conducted all of the interviews personally in order to provide a consistent evaluation of company data, in whatever form it existed. Sources are not identified for unpublished industry data.

The implementation costs were applied to the Model Plant workforce in order to develop a comprehensive cost estimate for Tier II implementation. The costs were estimated to be conservatively high and are presented in ranges, in order to reflect their variability and to protect the proprietary nature of some of the unpublished data. The range of estimates is considered to be relatively insensitive to errors in the assumptions.
Figure 3.3 illustrates the application of available cost information to the improvement required to estimate the costs for the example project organization to achieve an advanced level of Tier II implementation.

![Diagram showing the application of cost information to improvement required and costs]

**3.5 DETERMINE BENEFITS**

Benefits are primarily expected to result from increased productivity due to the improved skill levels and different work practices inherent in the Tier II strategy. Additional quantifiable benefits include improved safety and decreased absenteeism, turnover, and rework.

Quantitative information regarding benefits was applied to the Model Plant workforce in order to develop a comprehensive estimate of the benefits of Tier II implementation. The benefits were estimated to be conservatively low and are presented in ranges, in order to reflect their variability and to protect the proprietary nature of some of the unpublished data. The range of estimates is considered to be relatively insensitive to errors in the assumptions.
Figure 3.4 illustrates the application of available benefit information to the improvement required to estimate the benefits of achieving an advanced level of Tier II implementation on the example project.

![Diagram of determining benefits](image)

3.6 **CALCULATE BENEFIT-COST RATIO**

The final step was to calculate a range of benefit-cost ratios based on the estimates. The range of benefit-cost ratios provides a point of reference for the reader to evaluate the feasibility of implementing Tier II.

3.7 **SUMMARY**

This chapter described the development of the methodology used to determine the expected costs and benefits of an advanced level of Tier II implementation for the CII Model Plant. The methodology is summarized in the following steps:

1. Quantify the current state of the industry with respect to Tier II by using the Tier II metrics to evaluate the CCIS baseline data.
2. Identify requirements to improve from the Tier II Baseline score of 3.8/10 to an advanced level of 8/10.

3. Identify a project and workforce to use as a point of reference.

4. Estimate the costs of implementing Tier II at an advanced level on the example project.

5. Estimate the benefits of implementing Tier II at an advanced level on the example project.

6. Calculate a benefit-cost ratio to evaluate the feasibility of implementing Tier II at an advanced level on the example project.

Figure 3.5 illustrates the complete methodology model. Some of the terms have been made more generic than those presented in Figures 3.1 through 3.4 in order to make this more suitable for use by industry organizations.

![Methodology Diagram](image)

Figure 3.5: Methodology
This methodology can be used by industry organizations to evaluate their specific benefits and costs of implementation, by substituting, where available, their own current status and goals with respect to workforce development and management, information regarding costs and benefits, and information regarding their workforce organization (project or company level).
Chapter 4: Context of Tier II Implementation

This chapter presents detailed descriptions of the Tier II Project Baseline and the CII Model Plant workforce, and addresses some practical aspects of implementation.

The importance of short-interval planning in the Tier II strategy was a recurring theme in the meetings and interviews conducted with industry professionals. The consensus was that the scope and focus of all of the Tier II elements – technical skills, management skills, information technology utilization, and the training in general – should be such that the Tier II JCWs are able to effectively plan, lay out, and coordinate the flow of resources required for their crews’ work.

4.1 THE TIER II BASELINE

The “Tier II Baseline” indicates the current condition of the industry (represented by the individuals and projects in the CCIS workforce database) as measured by the Tier II Index. None of the baseline projects were deliberately pursuing a Tier II strategy based on the metrics at the time of the site visits. The unstated assumption is that the industry is not currently operating at an advanced level of Tier II implementation. The overall Tier II Index scores and the Tier II component scores calculated for the 20 projects in the CCIS workforce database are provided in Table 4.1 and summarized in Figures 4.1 and 4.2.
<table>
<thead>
<tr>
<th>Project Number</th>
<th>Union/Non-Union</th>
<th>Construction/Maintenance</th>
<th>Tier II Project Index (1-10)</th>
<th>Craft Tech. Skills (1-100)</th>
<th>Craft Mgt. Skills (1-100)</th>
<th>IT Utilization (1-100)</th>
<th>Craft Utilization (1-100)</th>
<th>Organization (1-100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>N</td>
<td>C</td>
<td>3.8</td>
<td>33</td>
<td>30</td>
<td>12</td>
<td>36</td>
<td>66</td>
</tr>
<tr>
<td>01</td>
<td>N</td>
<td>M</td>
<td>3.4</td>
<td>24</td>
<td>36</td>
<td>12</td>
<td>36</td>
<td>60</td>
</tr>
<tr>
<td>02</td>
<td>U</td>
<td>C</td>
<td>3.2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>03</td>
<td>U</td>
<td>C</td>
<td>5.9</td>
<td>56</td>
<td>61</td>
<td>20</td>
<td>56</td>
<td>100</td>
</tr>
<tr>
<td>04</td>
<td>N</td>
<td>M</td>
<td>2.7</td>
<td>30</td>
<td>38</td>
<td>0</td>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>05</td>
<td>U</td>
<td>M</td>
<td>3.8</td>
<td>36</td>
<td>55</td>
<td>0</td>
<td>42</td>
<td>58</td>
</tr>
<tr>
<td>06</td>
<td>N</td>
<td>C</td>
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<td>51</td>
<td>0</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>07</td>
<td>N</td>
<td>C</td>
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<td>44</td>
<td>37</td>
<td>0</td>
<td>37</td>
<td>24</td>
</tr>
<tr>
<td>08</td>
<td>N</td>
<td>C</td>
<td>2.9</td>
<td>32</td>
<td>51</td>
<td>0</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>09</td>
<td>N</td>
<td>M</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>N</td>
<td>C</td>
<td>3.3</td>
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<td>39</td>
<td>0</td>
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<td>38</td>
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<td>11</td>
<td>N</td>
<td>C</td>
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<td>54</td>
<td>6</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>12</td>
<td>U</td>
<td>C</td>
<td>6.3</td>
<td>85</td>
<td>97</td>
<td>20</td>
<td>60</td>
<td>51</td>
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<td>13</td>
<td>N</td>
<td>M</td>
<td>3.2</td>
<td>39</td>
<td>35</td>
<td>0</td>
<td>60</td>
<td>28</td>
</tr>
<tr>
<td>14</td>
<td>N</td>
<td>C</td>
<td>3.3</td>
<td>29</td>
<td>34</td>
<td>0</td>
<td>46</td>
<td>56</td>
</tr>
<tr>
<td>15</td>
<td>U</td>
<td>C</td>
<td>3.8</td>
<td>45</td>
<td>51</td>
<td>20</td>
<td>46</td>
<td>30</td>
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<td>20</td>
<td>46</td>
<td>65</td>
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<td>17</td>
<td>N</td>
<td>M</td>
<td>4.2</td>
<td>31</td>
<td>42</td>
<td>0</td>
<td>50</td>
<td>88</td>
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<tr>
<td>18</td>
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<td>C</td>
<td>4.1</td>
<td>29</td>
<td>23</td>
<td>38</td>
<td>50</td>
<td>62</td>
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<td>19</td>
<td>N</td>
<td>M</td>
<td>3.4</td>
<td>35</td>
<td>30</td>
<td>0</td>
<td>49</td>
<td>58</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
<td>2.7</td>
<td>24</td>
<td>23</td>
<td>0</td>
<td>36</td>
<td>20</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
<td>6.3</td>
<td>85</td>
<td>97</td>
<td>52</td>
<td>66</td>
<td>100</td>
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<td>61</td>
<td>73</td>
<td>52</td>
<td>30</td>
<td>80</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td><strong>3.8</strong></td>
<td><strong>38</strong></td>
<td><strong>44</strong></td>
<td><strong>11</strong></td>
<td><strong>49</strong></td>
<td><strong>50</strong></td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td></td>
<td><strong>3.5</strong></td>
<td><strong>34</strong></td>
<td><strong>39</strong></td>
<td>0</td>
<td><strong>48</strong></td>
<td><strong>53</strong></td>
</tr>
<tr>
<td>Mean/Median</td>
<td></td>
<td></td>
<td><strong>1.08</strong></td>
<td><strong>1.13</strong></td>
<td><strong>1.14</strong></td>
<td><strong>-</strong></td>
<td><strong>1.03</strong></td>
<td><strong>0.94</strong></td>
</tr>
<tr>
<td>Std. Dev.</td>
<td></td>
<td></td>
<td><strong>0.93</strong></td>
<td><strong>13.9</strong></td>
<td><strong>16.9</strong></td>
<td><strong>16.0</strong></td>
<td><strong>9.0</strong></td>
<td><strong>21.7</strong></td>
</tr>
</tbody>
</table>
Figure 4.1: Tier II Project Index Scores

Figure 4.2: Tier II Project Component Scores

8 The goal of an “advanced level of Tier II implementation” in this dissertation is an overall score of 8.
9 The goal of an “advanced level of Tier II implementation” could be approximated by a score of 80 for each component, although an overall Tier II score of 8/10 can be achieved through various combinations of component scores.
Table 4.1 and Figures 4.1 and 4.2 clearly indicate that the industry is not currently operating at an advanced level of Tier II implementation.

Castañeda-Maza (2002) individual receptiveness to the workforce development principles in Tier II using questions and responses on a 5-point Likert scale. Figure 4.3 displays the improvement potential (calculated as 10 minus the mean Tier II component score on a 10-point scale) vs. the individual receptiveness to the principles found in that component, where “1” represents low receptiveness and “5” represents high receptiveness. Note that technical training is the only Tier II component omitted in these data; individual receptiveness to Tier II technical training elements was not assessed.

![Improvement Potential vs. Receptiveness](image)

Figure 4.3: Improvement Potential vs. Individual Receptiveness

Figures 4.4 through 4.7 provide the detailed distribution of individual receptiveness responses for each component of Tier II, where “1” represents low receptiveness and “5” represents high receptiveness.
Figure 4.4: Individual Receptiveness – Management Skills

Figure 4.5: Individual Receptiveness – IT Utilization
Individual Receptiveness - Craft Utilization
Improvement Potential = 5.1

Figure 4.6: Individual Receptiveness – Craft Utilization

Individual Receptiveness - Organization
Improvement Potential = 5.0

Figure 4.7: Individual Receptiveness – Organization
Table 4.1, Figure 4.1 and Figure 4.2 show that action is needed for the industry to achieve an advanced level of Tier II implementation. Figures 4.3 through 4.7 indicate that the workforce is generally receptive of the concepts inherent in Tier II.

4.2 EXAMPLE PROJECT WORKFORCE

The scope of Tier II implementation is primarily intended for the key crafts – that is, those crafts having the greatest impact on the cost and schedule performance of the project. This distinction is not meant to arbitrarily limit the scope of implementation; rather, it is an effort to concentrate the workforce development investment where it can provide the greatest benefit.

As discussed in Chapter Three, this dissertation applies Tier II to the CII Model Plant as an example project. The key crafts for the Model Plant are electricians, instrumentation workers, millwrights, pipe fitters, structural ironworkers, and welders. These crafts represent approximately half of the total direct labor work hours for the Model Plant (Burleson 1997).

The example project organization is predicated on the baseline case (single skills) from the 1996 Model Plant multiskilling study (Burleson 1997). Because Tier II inherently includes multiskilling, this will yield a conservative (high cost) case for Tier II implementation. The “dualskill” strategy in the 1996 study was based solely on maximizing employment duration by an analysis of the resource demand curves. This resulted in some skill combinations with “no practical application,” and thus its use in this dissertation would most likely produce an underestimate of the cost required to implement Tier II (Burleson 1997). Table 4.2 shows the breakdown of total hires by craft.
The numbers of foremen and Tier II JCWs in the key crafts were determined by assumed ratios applied to the peak number of hires for each craft. The peak number is the appropriate starting point, because the foremen and Tier II JCWs are assumed to be “core” employees, and will likely be some of the first people on the project, as well as some of the last to leave. Rounding the results up creates a reasonable turnover rate of 4 to 5 percent for the foremen and Tier II JCWs. The peak number of hires for each key

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10 Adapted from Burleson (1997), Table 4.2 and Figure 4.4.
craft was divided into foremen and crewmembers using a 10:1 ratio, which was the average crew size reported by individuals on non-union projects in the CCIS workforce database. The crewmembers were then further divided into journey-level craft workers and helpers. A number of sources were considered regarding the percentages of journey-level craft workers and helpers per crew. The consensus estimate of the industry professionals interviewed in the Houston area was 45 percent journey-level craft workers. The average of non-union projects in the CCIS workforce database was 55 percent journey-level craft workers. Haas, et al. (2002a) presented an overall figure of 43 percent skilled direct labor hours for the Model Plant project (based on CII 1998). An analysis of the key craft data from Haas, et al. (2002a) produces a weighted average of 52 percent journey-level craft workers, as indicated in Table 4.3.

Table 4.3: Breakdown of Direct Labor Hours for Model Plant Key Crafts

<table>
<thead>
<tr>
<th>Division/Craft</th>
<th>Skilled Direct Labor Hours</th>
<th>Semi/Unskilled Direct Labor Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>Instrumentation</td>
<td>46%</td>
<td>54%</td>
</tr>
<tr>
<td>Steel Erection</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Major Equipment</td>
<td>40%</td>
<td>60%</td>
</tr>
<tr>
<td>U/G Pipe Installation</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>Pipe Fabrication</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>A/G Pipe Installation</td>
<td>55%</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Weighted Average</strong></td>
<td><strong>52%</strong></td>
<td><strong>48%</strong></td>
</tr>
</tbody>
</table>

Source: CII 1998


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11 All data except weighted average © 1988, CII Model Plant Update, CII, Austin, Texas.
Estimating Standards, which produced an estimate of 70 percent journey-level craft workers.

The Model Plant staffing plan was developed for a predominantly non-union situation (Burleson 1997) and the majority of the data collected for this dissertation is from Houston area non-union industrial contractors. Therefore, this assessment used a combination of crew mixes: key crafts were based on the percentages in Table 4.3, and all other crafts were based on 45 percent journey-level craft workers and 55 percent helpers. This combination best supports the available data from the CII Model Plant and from the industry interviews in the Houston area. It also produced a conservatively high number of Tier II JCWs required for a non-union implementation example, compared to the “composite” figures of 45 percent journey-level craft workers (industry interviews) and 43 percent journey-level craft workers (Haas, et al. 2002a).

Finally, the number of Tier II JCWs was calculated based on the standard in the Tier II metrics – that 40 percent of the key craft journey-level workforce should be Tier II JCWs. The scope of the Tier II implementation with respect to personnel is summarized below:

Table 4.4: Tier II Individuals for the Model Plant

<table>
<thead>
<tr>
<th>Trade Classification</th>
<th>Peak</th>
<th>FM</th>
<th>J CWs</th>
<th>Tier II JCWs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrician</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumentation Worker</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Millwright</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe Fitter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Steel Erector</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>22</td>
<td>42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The 42 Tier II JCWs represent approximately 20 percent of the peak number of journey-level craft workers in each craft for the entire project, and less than 7 percent of the total hires. The training requirements in the following chapter will be applied to these 22 foremen and 42 Tier II JCWs in order to produce a project with sufficient Tier II individuals in the key crafts.

4.3 PRACTICAL ASPECTS

4.3.1 A New Paradigm

During the initial development of the Two-Tier strategy, it was thought that a given project would be managed with either a Tier I or a Tier II approach (Borcherding, et al. 2001). As this study into the implementation of Tier II progressed, a new paradigm emerged regarding the workforce development aspects of Tier II. Both the collected data and interviews with industry professionals indicated that there are actually two workforces within the construction workforce. This dissertation refers to these workforces as “core” and “transient.” The core workforce is comprised of craft workers who stay with one company through a number of projects. The transient workforce is comprised of craft workers who are hired specifically for one project, and who may or may not continue with the company after that project.

Considering the historical barriers to workforce development in the construction industry, and based on interviews with industry professionals, a proposed new approach is that a contractor or owner pursue a Tier II strategy with its core workforce, and a Tier I strategy with its transient workforce. Both Tier I and Tier II could exist on any given project; based on effective management theory, each strategy would be applied to the appropriate personnel, and could be implemented by areas, by trades, or by crews.
To a certain extent, Tier I and Tier II require the same functions; the difference is in who performs them – Tier I focuses on field supervision, and Tier II focuses on Tier II JCWs. Tier I adopts many of the concepts presented in BRT (1982a), “First and Second Level Supervisory Training” (Brandenburg 2004). The premise is that training supervisors in management and communication skills can improve productivity. Tier II takes this one step further, by implementing these skills through Tier II journey-level craft workers as well.

In this paradigm, the core foremen form the foundation to effectively manage the Tier I portion of the project, and the core journey-level craft workers form the foundation to effectively manage the Tier II portion of the project. Transient craft workers would be predominantly assigned to Tier I crews, but would also be assigned to fill out Tier II crews, which may operate as supervised teams.

This approach invests the majority of the training and development effort in the contractor’s core foremen and journey-level craft workers, which reduces the potential loss of that investment and provides a level of comfort with the contractor regarding the individual to be invested in. A Bureau of Labor Statistics news release on employee tenure reported that the median tenure for employed wage and salary construction trade workers with their current employer was 3.3 years. This figure varied from 2.6 years to 3.5 years between 1983 and 2002 (BLS 2002). The CCIS surveys asked respondents to indicate their length of tenure with their current employer. The median tenure reported by 575 journey-level craft workers was 1.5 years, and the median reported by 135 foremen was 2.3 years. Looking specifically at those individuals on construction projects, 394 journey-level craft workers reported a median tenure of 1.0 years, and 105 foremen reported a median tenure of 2.0 years. The average in the CCIS database is admittedly influenced by a small number of high-tenure individuals, but this is an
important point in the context of Tier II, which focuses on a select subset of journey-level craft workers. The average response from all journey-level craft workers was 4.1 years, and response from those on construction projects was 3.0 years. Of the 499 foremen and journey-level craft workers on construction projects, 142 (28 percent) reported tenures of 3 years or longer.

This dissertation treats the Model Plant as a “Tier II project” in accordance with the original concept of Tier II (Borcherding, et al. 2001). Developing an assessment under this new paradigm (Tier I through core foremen and Tier II through core journey-level craft workers) is not feasible without creating detailed assumptions about the quantity and characteristics of hypothetical core and transient workforces available to the contractor. For purposes of this dissertation, the contractor is assumed to have enough core personnel for at least the majority of the Tier II positions. The project-based approach is still appropriate because the majority of construction financial and production data are maintained on a project basis, and the Tier II metrics are project-based. Some organizations may choose to base their implementation efforts on their core foremen and journey-level craft workers available to them, however. Some may also consider the highly skilled workers who rotate among a small group of employers as core workers, and choose to invest in their development, knowing that they will gain the benefit of their performance, even if not exclusively. This approach could be carried out by an individual company or by a number of cooperating companies with the goal of developing a skilled regional workforce.

4.3.2 Implementation on Union Projects

This dissertation discusses the implementation of the Tier II strategy in the context of a predominantly non-union environment. This is not meant to exclude union construction by any means. It simply reflects the assumptions of the CII Model Plant
multiskilling study and the demographics of the industry (approximately 80 percent non-union) and of the Gulf Coast area, where much of the field data were collected. Tier II provides great potential for both sectors of the industry, and may in fact provide a viable strategy for the union sector to strengthen its market position. Union representatives were enthusiastic participants in both of the Tier II metrics-development workshops in 2001. Joint labor/management apprenticeship programs have long provided quality technical training. Some consider the union workforce to have greater potential for high productivity, due to skills developed through the structured apprenticeship programs. Ray Marshall (1996) claimed that “with mutual acceptance and respect between unions and managers, unionized firms can achieve higher performance than can nonunion firms.” In fact, some union contractors base their business model on achieving better productivity than their non-union competitors (Pappas 2000).

There may currently be some practical limits to multiskilling and multicrafting in the union sector, as individuals are generally limited to the skills and crafts in their locals, but these limitations may not be consequential. Some of the current discussion in the industry regarding multicrafting may actually be an unintended consequence of the task training approach of the non-union sector, which has resulted in more craft divisions than in the union sector. The International Brotherhood of Boilermakers has included welding certification in its joint apprenticeship program since 1989, and approximately 11,000 union boilermakers hold current welding certifications (IBB 2004). Welding is also included in the pipe fitter and structural ironworker apprenticeship programs. The pipe fitter and electrician apprenticeship programs include instrumentation training. The United Brotherhood of Carpenters and Joiners of America “offers every member continuing and developmental training in all [eight] specialties. Many have become
proficient in numerous trades.” (UBC 2004). Unions also utilize composite crews (individuals from different trades) for tasks that lend themselves to multicrafting.

Some apprenticeship programs in the Houston area are beginning to include training that supports some of the management skills identified in Tier II. To a large extent, contractors and owners have not yet identified these management skills as needs.

4.3.3 Implementation on Maintenance Sites

Maintenance sites have some inherent benefits over construction sites with respect to some of the Tier II goals. The longevity of the workforce at a maintenance site lends itself to more training opportunities, closer working relationships, more trust, better communication, and, as a result, perhaps a better atmosphere for a more autonomous Tier II work team approach. The relatively stable atmosphere of maintenance work can also provide more beneficial opportunities for measuring and quantifying benefits.

4.4 SUMMARY

This chapter presented the Tier II Baseline, which indicates that the industry has significant room to improve based on the Tier II metrics. The average baseline project score was 3.8 (on a scale of 1 to 10); the scores ranged from 2.7 to 6.3, but only 6 of the 20 projects scored higher than 4.0, and only 2 projects scored higher than 4.4. The average baseline component scores ranged from 11 to 50 (on a scale of 1 to 100), and four of the five components exhibited a range of scores greater than 50. IT Utilization represents the greatest potential for improvement, as the average score was 11 out of 100. The baseline, at various levels of detail, indicates that there is significant room for improvement, both in the scores themselves and in the variability or predictability of the scores.
Worker responses to the questionnaires indicate that they are most receptive to the elements comprising the management skills, organization, and information technology utilization components of the Tier II strategy. Workers are slightly receptive to the craft utilization component – or multiskilling; this was the only component for which greater than 10 percent of the responses were “not desirable.”

The Model Plant workforce for the implementation example was developed – 22 foremen and 42 journey-level craft workers are required in Tier II positions in the key crafts. The use of Burleson’s (1997) baseline case (no multiskilling) produces a conservatively high number of Tier II individuals required for the example project.

Specific thoughts were presented regarding the implementation of Tier II predominantly through core employees, and on union projects and maintenance sites.

The next chapter explores the level of effort required to achieve a Tier II score of 8 out of 10 on the CII Model Plant, assuming that the Tier II Baseline represents the current workforce.
Chapter 5: Level of Effort Required for Implementation

This chapter identifies and quantifies the specific requirements to achieve an advanced level of Tier II implementation on the CII Model Plant, based on the methodology detailed in Chapter Three and the context described in Chapter Four.

5.1 Project Craft Technical Skills

The historical foundation of construction workforce training and development is technical training. Individual craftsmen successfully trained apprentices for centuries, prior to the development of modern-day union apprenticeship programs and the more recent non-union training programs (Maloney and McFillen 1995). The non-union technical training approach has predominantly been executed on a company basis, and with a focus on task training. Tier II changes this focus to the development of a well-rounded journey-level craft worker.

5.1.1 Requirements from Tier II Metrics

At the individual level, Tier II evaluates certification at the journey level, multiskilling/multicrafting, technical experience, and continuous training and education, as shown in Figure 5.1.
<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craft Certification</td>
<td>4.0</td>
<td>Certified in 3 crafts.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 2 crafts.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certification.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Technical Experience</td>
<td>4.0</td>
<td>More than 10 years of experience at the certified craft level.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 years of experience at the certified craft level.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 1 year of experience at the certified craft level.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Continuous Training and Education</td>
<td>2.0</td>
<td>More than 200 hours of training and skill updating in the last 3 years.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 hours of training and skill updating in the last 3 years.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training or skills updating since first craft certification.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.1: Tier II Individual Technical Skills

At the project level, the Tier II Technical Skills component is based on individual technical skills scores and the percentage of Tier II JCWs in the journey-level workforce. The Project Technical Skills component is shown in Figure 5.2.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score from Individual Evaluation on Technical Skills *</td>
<td>7.0</td>
<td>Greater than 75 points.</td>
<td>10</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 points.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 25 points.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>% of Tier II workers</td>
<td>3.0</td>
<td>40% or more of journeymen are certified as Tier II workers.</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% of journeymen are certified as Tier II workers.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 10% of journeymen are certified as Tier II workers.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

* For project’s key crafts.

Figure 5.2: Tier II Project Craft Technical Skills component
The term “craft certification” requires definition. During the data collection phase, participants were told that this term meant any certification recognized by their company that qualified them to work at the journey level. Examples included a union journeyman card, NCCER certification, or a company training certification. As the study progressed, industry professionals stressed that this term should refer to “certified plus” for NCCER training – that is, the individual is considered certified per the Tier II metrics after passing both the written test and performance verification for a given craft. This is a more stringent requirement than originally considered, but it is a realistic goal for the future. The craft certification data presently contained in the CCIS workforce database are significantly more lenient than this definition, and the early CCIS vision of multiskilling did not require a “certified plus” level of expertise in secondary crafts (Burleson 1997):

In a construction context, [multiskilling] does not necessarily mean that a worker obtains or possesses mastery level skills in multiple trade areas. However, based on the flexible application of skills the worker already possesses or is willing to acquire, the worker can be an effective and productive contributor to the work output of trade disciplines other than his/her primary trade.

This issue certainly deserves additional consideration, and may require that the metric be updated to reflect this new terminology used in the non-union sector.

The terms “multiskilling” and “multicrafting” are fairly self-explanatory, but previous studies have used the terms somewhat interchangeably. It is important to recognize that there is a difference between the two, and that one may be more appropriate than the other in a particular set of circumstances. Industry professionals from the non-union sector have stated that Tier II should specify multicrafting, where “crafts” are generally defined by different NCCER training curricula. For instance, pipe fitting, instrumentation, and welding are generally considered three crafts in the non-union sector; the union sector considers pipe fitting a craft, and instrumentation and
welding skills within that craft. Regardless of the semantics, the strategic intent of multiskilling in Tier II is to train individuals in a practical combination of technical skills in order to meet the industry goals of retaining them on the project for a longer period of time and reducing the number of total hires required (Burleson 1997; Haas, et al. 1999a; Haas, et al. 1999b). A “master list” of Tier II skills and/or crafts should be developed to improve the understanding of the terms and the standardization of the data, at least with respect to Tier II.

Another term that needs clarification is “continuous education and training.” In the baseline data collection process, participants were told that this included safety training and classroom training, but it only included on-the-job training that was recognized by the contractor as training; work experience did not count as on-the-job training for this purpose. In the future, contractors should develop standards with respect to supervision, evaluation and testing, and documentation of on-the-job training in order for it to count toward this requirement. “Continuous education and training” should include all training officially recognized and documented by the contractor, including safety training, technical training, and management/ supervisory training.

5.1.2 Current Industry Status

The average number of craft certifications reported by 770 foremen and journey-level craft workers was 1.5, which generates a score of 3.75/10 for the craft certification element. The median response, 1 craft, generates a score of 2.5/10.

The average amount of experience reported after certification was 13.1 years, and the median was 11 years, which both generate a score of 10/10 for the craft certification element.

The average amount of continuous training and education reported in the last 3 years was 161 hours, which generates a score of 4.7/10 for the continuous training and
education element. The median response, 20 hours, generates a score of 1.0/10. The median response is more reflective of the current state of the industry for this element, because the average is heavily influenced by 22 individual responses of greater than 1,200 hours of training.

The issue of continuous training deserves further discussion in light of the “core workforce” implementation concept. The survey question was, “How many hours of craft training and craft skill updating have you had in the last 3 years (including recertification and safety)?” Therefore, it is instructive to specifically look at those journey-level craft workers and foremen who reported a tenure of three years or more, because (1) they have a “core workforce” level of tenure with their current employer, and (2) the amount of training they reported in the last three years was, by definition of the question, provided by their current employer. Table 5.1 provides the distribution of continuous training reported.

Table 5.1: Continuous Training Reported by Foremen and Journey-Level Craft Workers with at least Three Years of Tenure

<table>
<thead>
<tr>
<th>Total Data Set</th>
<th>Construction Projects only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
</tr>
<tr>
<td>0 hours</td>
<td>88</td>
</tr>
<tr>
<td>1-24 hours</td>
<td>51</td>
</tr>
<tr>
<td>25-119 hours</td>
<td>89</td>
</tr>
<tr>
<td>≥120 hours</td>
<td>46</td>
</tr>
<tr>
<td>TOTAL</td>
<td>274</td>
</tr>
</tbody>
</table>

Although more than half of these “long-tenure” individuals were on maintenance sites, there is very little difference in the amount of training provided on construction projects compared to the overall data set. It is important to note that approximately one-third of these “core” employees reported no training in the previous three years, and that
more than one-half received 24 hours (8 hours per year) or less. Tier II requires 200 hours of training over three years for a score of 10; only 12 percent reported that amount of training. The median responses were 24 hours of training (for the total data set) and 16 hours of training (for construction projects only). There is no relationship ($R^2<0.01$) between tenure and continuous training and education for either group represented in Table 5.1. The fact that so many of these “long-tenure” individuals received so little training over the last three years is a significant point of concern.

5.1.3 Implementation Requirements

The following goals were established to achieve an advanced level of implementation on the example project:

- 22 foremen and 42 Tier II JCWs certified in 2 crafts.
- The CCIS workforce database indicates more than 10 years of experience at the certified level; no action is required.
- 22 foremen and 42 Tier II JCWs receive 200 hours of continuous education and training over three years.
Table 5.2 summarizes the individual and project technical skill element scores for the baseline and the goal (maximum = 10):

Table 5.2: Individual and Project Technical Skill Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Technical Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Craft Certification</td>
<td>3.8</td>
<td>2.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Technical Experience</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Continuous Training and Education</td>
<td>4.7</td>
<td>1.0</td>
<td>10.0</td>
</tr>
<tr>
<td><strong>Project Craft Technical Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Score from Individual Evaluation on Technical Skills</td>
<td>5.1</td>
<td>5.0</td>
<td>10.0</td>
</tr>
<tr>
<td>% of Tier II Workers</td>
<td>0.8</td>
<td>0.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

The following requirements are necessary to increase the baseline Project Technical Skill Component score (maximum = 100) from a mean of 38.0 and a median of 33.8 to the goal of 85.0:

- Technical training to upgrade 64 individuals from 1.5 to 2 certified crafts. Based on interviews of industry professionals using in-house instructors and NCCER materials, this cost would range between $2,000 and $5,000 per person.

- Assume that the continuous education and training requirement (upgrading 64 individuals to 200 hours every 3 years) will be met through a combination of the technical skills training, management skills training, information technology training, and communication/teamwork training described in those sections.

\[12\] 42 Tier II JCWs ÷ 209 peak JCWs for all crafts = 20%.
An on-site training coordinator is recommended to manage the comprehensive training program at the project, including the estimation or measurement of training costs and benefits. The estimated cost is $45,000 per year, plus 43 percent benefits\textsuperscript{13}.

The implementation of multiskilling and multicrafting deserves some significant attention, especially if the concept is new to the organization. Multiskilling provides more flexibility for the individual and for the employer (Burleson 1997). Organizations should approach multiskilling with a strategic viewpoint. It requires more than just training; Villalobos (1997) stated that a multiskilling program “should address recruiting, training, and compensation policies.”

Burleson (1997) addressed three major issues regarding the implementation of multiskilling:

- “[A] workforce ‘paradigm shift’ is required throughout the industry. To utilize a multiskilled labor strategy, employers must alter their screening and hiring practices, compensation practices, staffing practices, and project management principles. Greater communication between employer and employee will be needed. Also, workers must see themselves in a new light. In a multiskilling environment, they are no longer ‘skill for hire’ with few company, project, or regional attachments. They are highly skilled and diversely utilized employees with strong attachments to a company or complete project. They must personally commit to increased training and skill development.”

- “The availability of training and nationally standardized training curriculums.”

\textsuperscript{13} Average for construction industry, March 2004. \url{www.bls.gov/news.release/ecenr0.htm}.
• “[I]nitial resistance in the unionized new construction sector.”

Some combinations of skills or crafts are naturally more desirable or useful than others. Contractors should identify desirable combinations of skills that provide the most value to the company as well as to the individual.

It is a reasonable assumption that the market exhibits some natural efficiency, and therefore it is instructive to look at the combinations of crafts recorded in the CCIS workforce database as a preliminary indicator of valuable combinations. The database includes 505 foremen and journey-level craft workers with primary crafts in one of the key crafts for the Model Plant (electrician, instrumentation worker, millwright, pipe fitter, structural ironworker, and welder). They are listed in order from most to least multicrafting, along with the most common skill combinations.

• Structural ironworkers (n=80) – 88 percent are multicrafted. The most common secondary crafts are rigger (65 percent), welder (51 percent), boilermaker (24 percent), equipment operator (20 percent), and millwright (19 percent).

• Millwrights (n=47) – 70 percent are multicrafted. The most common secondary crafts are structural ironworker (36 percent), rigger (30 percent), welder (28 percent), equipment operator (21 percent), and pipe fitter (19 percent).

• Pipe fitters (n=121) – 60 percent are multicrafted. The most common secondary crafts are boilermaker (32 percent), rigger (21 percent), welder (21 percent), instrument worker (15 percent), and structural ironworker (12 percent).

• Welders (n=98) – 58 percent are multicrafted. The most common secondary crafts are boilermaker (30 percent), structural ironworker (27 percent),
percent), pipe fitter (24 percent), rigger (17 percent), and millwright (15 percent).

- Instrument workers (n=17) – 53 percent are multicrafted. The most common secondary crafts are electrician (29 percent) and pipe fitter (18 percent).
- Electricians (n=142) – 25 percent are multicrafted. The most common secondary crafts are instrument worker (13 percent) and welder (10 percent).

An interesting observation is that there is a significant amount of “cross” multicrafting within these six key crafts.

One contractor provided a list of its preferred multicrafting combinations, which are very similar to the information from the CCIS workforce database and are listed in no particular order:

- Pipe fitter/Boilermaker,
- Welder/Pipe fitter,
- Electrician/Instrument Fitter,
- Ironworker/Rigger/Operator,
- Carpenter/Cement Finisher/Reinforcing Ironworker,
- Scaffold Builder/Carpenter/Reinforcing Ironworker, and
- Painter/Insulator/Sheet Metal Worker.

The construction implementation of high performance work teams documented by Chapman and Gerson (1999) utilized the following combinations:

- Millwright/Instrumentation worker,
- Ironworker/Rebar or Rigger,
- Millwright/Pipe fitter,
Electrical/Instrumentation worker.

This particular contractor learned valuable lessons regarding multicraft workers: “The teams performed at times as multicraft teams. Considerable skepticism remained on the part of some craftsmen about multicraft work, however, with [welders] being the most reluctant.” (Chapman and Gerson 1999). Baseline data indicate that this may no longer be a significant barrier; 58 percent of the welders claimed certification in more than one craft.

Some companies may consider a radical restructuring or organizational change to develop a multicrafted culture. Burleson (1997) developed some theoretical concepts with respect to combining trades from an organizational standpoint. The Naval Construction Force (Navy Seabees) is an example of inherent multicrafting through organizational structure. All construction crafts are combined into seven military ratings: Builder, Construction Electrician, Construction Mechanic, Engineering Aide, Equipment Operator, Steelworker, and Utilitiesman (Hyatt, Pappas, and Haas 2004).

5.1.4 Likely Barriers

Barriers to improving technical skills include:

- Risk of lost investment due to personnel turnover.
- Difficulty in determining the payback or benefit in terms of increased productivity.
- Cost, and who should pay for it. “The cents-per-hour voluntary contribution method has worked only in a few areas. Generally, it has not received broad support from owners because, with a few exceptions, they have no confidence in or cannot validate that contractors are actually directing part of their compensation to the training area.” (BRT 1997).
Barriers to multiskilling and multicrafting include:

- Artisan pride (Ohno 1984).
- Resistance from individual workers, the traditional hierarchical management structure, training requirements, wage implications, and the deterioration of unused skills (Burleson 1997, Carley 1999).

The persistence of the skilled labor shortage demands that reluctance to invest in human assets must no longer be accepted as an excuse not to train. Owners and contractors must develop methods to correlate training effects on productivity, retention and other benefits. A skilled workforce is a foundational element to cost-effective construction. “Owners should consider that it is in their self interest to ensure that sufficient funding and effective programs for training craftsmen are provided to meet future needs.” (BRT 1982d). There are published examples of owners requiring contractors to invest in training, which removes the possibility that one contractor can underbid all of the others and win work while ignoring the development of its workforce (NCCER 2003c).

5.2 PROJECT CRAFT MANAGEMENT SKILLS

Crews rely on technical skills to physically build the project, but the effective use of project management skills is what ensures crews have the resources they need, when they need them, so they can work productively (Evans 1999, Pappas 2000, Hickok 2003). As presented earlier, the goal of requiring management skills at the Tier II JCW level is to equip them to effectively plan, lay out, and coordinate the flow of resources required for their crews’ work. The dynamic nature of a construction project makes it essential for the short-interval planning system to be quick and responsive. When this system is designed around Tier II JCWs, the ability to deal with change is located at the work face instead of in the office.
There is much support in the literature for this type of management approach. Maloney and McFillen (1995) recommended “adding managerial tasks to the technical or manual tasks performed by the worker.” The effectiveness with which these skills are employed has wide-ranging effects on a project. Experienced field supervisors emphasized that “significant attention to planning would be vital” to the success of a high performance work team effort (Chapman and Gerson 1999).

“Training is most cost effective when it is designed to accomplish a specific need.” (BRT 1982b). Therefore, management skills training should be designed specifically to support the processes and systems used by the company and on the project.

The importance of an effective short-interval planning process is magnified when working overtime (CURT 2004a). Short-interval planning generally consists of:

- Sequencing of the work,
- Coordination of resources (tools, equipment, people, and crews), and
- Some form of “work package” that provides a structured approach to ensuring resources are available, and also provides documentation of the planning/coordination completed.

Work packages “should include the work scope, the basic schedule, materials, and the list of skills required for each activity.” (Haas, et al. 1999b). It is to be expected that work packages will have varying levels of detail, depending on the trade involved and the scope of the work assignment. The basic purpose is to define the scope of the task and to address the resource requirements so that proper preparations can be made, and causes of inefficiency removed, prior to the scheduled start of the task.

There are a number of tools available to assist contractors with short-interval planning, including the Last Planner System® and the “Percent Planned, Complete” metric. Foreman Delay Surveys and in-depth craft worker questionnaire surveys can
pinpoint specific problems with the effectiveness of the planning system. The key to productivity is to remove obstacles before they impact the crews.

### 5.2.1 Requirements from Tier II Metrics

At the individual level, Tier II evaluates certification in administrative, computer, and planning skills and job management functions; and individual performance documented in a quantified work record, as shown in Figure 5.3.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative Skills</td>
<td>1.0</td>
<td>Certified in at least 4 administrative skills.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 2 administrative skills.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certified administrative skills.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Computer Skills</td>
<td>1.0</td>
<td>Certified in at least 5 computer skills.</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 3 computer skills.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certified computer skills.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Planning Skills</td>
<td>3.0</td>
<td>Certified in planning skills.</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160 hours of training but not certified in planning skills.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training and certification.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Job Management Skills</td>
<td>2.0</td>
<td>Certified in job management functions.</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160 hours of training but not certified in job management functions.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training and certification.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Work Record</td>
<td>3.0</td>
<td>Superior in all categories.</td>
<td>10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superior in some, modest in others.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak in most categories.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.3: Tier II Individual Management Skills

The particular skills desired were identified by Borcherding, et al. (2001):

- Administrative skills: cost management, scheduling, material management, RFI management, and estimating.
- Computer skills: email/internet, word processing, spreadsheet, scheduling, estimating, CAD, and material management.
- Planning skills: material, equipment, tools, information, short-term planning, and scheduling.
- Job management functions: crew coordination, inter-and intra-craft coordination, selection of work means and methods, and leadership.

At the project level, the Tier II Management Skills component is based on individual management skills scores. The Project Craft Management Skills component is shown in Figure 5.4.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score from Individual Evaluation on Management Skills *</td>
<td>10.0</td>
<td>Greater than 75 points.</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 points.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 25 points.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

* For project's key crafts.

Figure 5.4: Tier II Project Craft Management Skills component

The significant assumption has already been presented; it is that the extent to which Tier II JCWs need management skills is to allow them to perform effective short-interval planning for their crews. For instance, the “CAD” requirement essentially means the understanding and basic manipulation of electronic drawings using the project’s equipment. The goal of the administrative skills is for the Tier II JCW to understand the impacts of various actions and delays on the jobsite, and to become more proactive in preventing and solving problems because of that understanding. The goal of the computer skills is for the Tier II JCW to use the project systems to facilitate planning.
A clarification is in order regarding the term “certified.” Few certifications are currently available for these skills. The questionnaire asked participants to indicate in which administrative and computer skills they were proficient, and whether they were certified and/or proficient in planning and job management skills. Proficiency was defined as “a skill in which you are competent and capable with little or no supervision.” For purposes of the initial baseline data collection, for administrative and computer skills, proficiency was accepted as certified. For planning and job management skills, 2.5 points each were awarded for proficiency and certification, and 5 points were prorated based on the standard of 160 hours of training. Until company certifications become common in the industry, these were determined to be the most appropriate methods of scoring these elements. These training questions referred to an individual’s entire construction career, as opposed to the three-year timeframe specified for “continuous education and training” in section 5.1.
5.2.2 Current Industry Status

The average number of administrative skills reported was 1.4 (proficient, not certified), which generates a score of 3.5/10 for the administrative element. The median response, 1 skill (proficient, not certified), generates a score of 2.5/10. Figure 5.5 indicates the percentage of respondents reporting proficiency in each of the 5 administrative skills; 55 percent of the respondents claimed proficiency in at least one skill.

![Proficiency in Administrative Skills](image)

Figure 5.5: Percentage of Responses – Proficiency in Administrative Skills

The average number of computer skills reported was 1.2 (proficient, not certified), which generates a score of 1.7/10 for the computer element. The median response, 1 skill (proficient, not certified), generates a score of 1.3/10. Figure 5.6 indicates the percentage...
of respondents reporting proficiency in each of the 7 computer skills; 51 percent of the respondents claimed proficiency in at least one skill.

Figure 5.6: Percentage of Responses – Proficiency in Computer Skills

Responses to the question about planning skills indicated that 8 percent of participants were certified, and an additional 48 percent were proficient. The average amount of training reported was 110 hours, but the median was 0 hours. The median response is more reflective of the current state of the industry for this element, because the average is heavily influenced by 21 individual responses of greater than 1,000 hours of training. The average individual score was 2.5/10 (median score = 2/10) as scored with the baseline criteria. As with continuous education, the issue of planning skills deserves more study. Table 5.3 illustrates the distribution of training for planning skills.
Table 5.3: Planning Skills Training Reported by Foremen and Journey-Level Craft Workers

<table>
<thead>
<tr>
<th>Amount of Training</th>
<th>Total Data Set</th>
<th>Tenure ≥3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Pct of Total</td>
</tr>
<tr>
<td>0 hours</td>
<td>467</td>
<td>61%</td>
</tr>
<tr>
<td>1-79 hours</td>
<td>169</td>
<td>22%</td>
</tr>
<tr>
<td>80-159 hours</td>
<td>45</td>
<td>6%</td>
</tr>
<tr>
<td>≥160 hours</td>
<td>89</td>
<td>12%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>770</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Note that 61 percent of the baseline participants have received no planning skills training and only 12 percent have received the full Tier II recommendation of 160 hours. Again, there is no relationship ($R^2 < 0.01$) between tenure and training for planning skills.

Responses to the question about job management functions indicated that 9 percent of participants were certified, and an additional 43 percent were proficient. The average amount of training reported was 128 hours, but the median again was 0 hours. The median response is more reflective of the current state of the industry for this element, because the average is heavily influenced by 26 individual responses of greater than 1,000 hours of training. The average individual score was 2.5/10 (median score = 2/10) as scored during the baseline. This issue also deserves more detailed analysis. Table 5.4 illustrates the distribution of training for job management functions.
Table 5.4: Job Management Training Reported by Foremen and Journey-Level Craft Workers

<table>
<thead>
<tr>
<th>Amount of Training</th>
<th>Total Data Set</th>
<th>Tenure ≥3 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Pct of Total</td>
</tr>
<tr>
<td>0 hours</td>
<td>473</td>
<td>61%</td>
</tr>
<tr>
<td>1-79 hours</td>
<td>142</td>
<td>18%</td>
</tr>
<tr>
<td>80-159 hours</td>
<td>48</td>
<td>6%</td>
</tr>
<tr>
<td>≥160 hours</td>
<td>107</td>
<td>14%</td>
</tr>
<tr>
<td>Total</td>
<td>770</td>
<td>100%</td>
</tr>
</tbody>
</table>

Note that 61 percent of the baseline participants have received no job management training, and only 14 percent have received the full Tier II recommendation of 160 hours. This distribution closely resembles that for planning skills training, and again there is no relationship ($R^2<0.01$) between tenure and training for job management skills.

The average work record score was 8.4, which generates a score of 8.4/10 for the work record element. The median response, 9, generates a score of 9/10.

5.2.3 Implementation Requirements

The following goals were established to achieve an advanced level of implementation on the example project:

- 22 foremen and 42 Tier II JCWs certified in 2 administrative skills. For purposes of the example project, material management and RFIs were considered the most valuable to enhance Tier II JCW participation in the short-interval planning process. For industry implementation, these skills will need to be selected on a case-by-case basis to support the specific role of Tier II JCWs in the organization’s planning process.
- 22 foremen and 42 Tier II JCWs certified in 3 computer skills. For purposes of the example project, scheduling, CAD (manipulation of drawings), and material management were considered the most valuable to enhance Tier II JCW participation in the short-interval planning process. For industry implementation, these skills will need to be selected on a case-by-case basis to support the specific role of Tier II JCWs in the organization’s planning process.

- 22 foremen and 42 Tier II JCWs certified in planning skills.

- 22 foremen and 42 Tier II JCWs certified in job management functions.

- The CCIS workforce database indicates a median work record score of 9; no further action is required.

Table 5.5 summarizes the individual and project management skill element scores for the baseline and the goal (maximum = 10):

Table 5.5: Individual and Project Management Skill Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Individual Management Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrative</td>
<td>3.5</td>
<td>2.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Computer</td>
<td>1.7</td>
<td>1.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Planning</td>
<td>2.5</td>
<td>2.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Job Management</td>
<td>2.5</td>
<td>2.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Work Record</td>
<td>8.4</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>Project Craft Management Skills</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Score from Individual</td>
<td>4.4</td>
<td>3.9</td>
<td>10.0</td>
</tr>
<tr>
<td>Evaluation on Management Skills</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The following requirements are necessary to increase the baseline Project Management Skill Component score (maximum = 100) from a mean of 44.0 and a median of 38.5 to the goal of 100.0:

- Training to upgrade 64 individuals from 1 to 2 administrative skills.
- Training to upgrade 64 individuals from 1 to 3 computer skills.
- Training and certification for 64 individuals in planning skills.
- Training and certification for 64 individuals in job management skills.
- Recordkeeping of quantifiable performance records.

The workforce is more receptive to improvement in this area than in any other (Castañada-Maza 2002; see also Figure 4.3). Detailed responses regarding receptiveness to the management skills concepts in the Tier II metrics are provided in Figure 4.4.

Based on industry interviews, training for planning and job management is generally introduced at the foreman level, but intensive training is not typically provided until an individual is a general foreman or superintendent. There is admittedly some overlap in the requirements between the administrative, computer, planning, and job management skills identified in the metrics. This overlap is also evident in the training that is commercially available. Here are some examples from published sources that address some of the topics required by the Tier II metrics:

- Contren® has three courses that are typically taught on-site. The Project Supervisor and Project Management courses each cost $95 per book and $110 per instructor guide. The Introduction to New Crew Leader course costs $40 per book and $60 per instructor guide (Contren® 2004).
- The NCCER Supervisor Academy is a one-week, 60-hour course that costs $1895. Adding $500 for travel and 60 labor hours at $27.17 per hour yields a total cost of $4,300 (Contren® 2004).
The Better SuperVision Training Program in Alberta, Canada consists of 74 hours of classroom instruction followed by a three month “on the job coaching period.” The training costs $900 per person, and 1,000 people have completed the course since its development in 1995 (CLRA 2004).

Some community colleges offer courses that support Tier II management skills, especially in the area of computer skills. These typically range from $400-$500 per course, and would most likely be taken on personal time.

It is not likely that commercially-available training will be completely sufficient for Tier II. While packaged courses are probably suitable for the teaching of theoretical aspects of these subjects, practical application is also required due to the unique nature of project controls. Practical application allows the trainee to use the project systems, and thus this portion of the training must be tailored specifically to the company and/or the project. Some amount of practical application training would be required for every individual who has not yet worked with the project’s systems, regardless of the extent of previous training and experience with other companies.

Unpublished sources of data for management skills training are primarily contractors who have developed their own “supervisor academies” – these are typically 40 hours or more, and are led by an in-house instructor. Assuming a 40-hour class for 10 students, a total compensation rate of $27.17, and an instructor wage rate of $30 for the course and additional preparation time, this would cost approximately $1,500 per person. One contractor has a 16-hour course which costs approximately $650 per person. One contractor has two in-house courses, totaling 88 hours, which together cost approximately $3,500 per person, but the contractor plans to revise and shorten them in the near future.
Based on the information available, a conservatively high cost estimate for these management skills training costs would be $3,500 per person. Because approximately half of the individuals in the CCIS workforce database are already proficient in these areas, we will use a range of $2,000 to $3,500 per person to achieve a company-recognized certification level of expertise.

Some projects may also consider the services of a consultant to assist with establishing a short-interval planning system, if needed. A rough cost estimate for a total of 30 days over the 18-month construction duration would be approximately $50,000. This would provide an independent perspective on the project’s progress and planning, as well as valuable on-the-job training opportunities for short-interval planning. The larger cost of short-interval planning, however, is the labor cost for key craft foremen and Tier II JCWs to actually do the planning. Foremen in a case study using the Last Planner System® spent four to six hours per week doing short-interval planning at the beginning of the project, but as they became more efficient planners, this decreased to approximately one hour per week (Pappas 2000). Some of this planning normally occurs during the workday. Assuming that the project pays 2 hours of overtime per week for short-interval planning, and considering the requirements of the weekly staffing plan (Burleson 1997), a reasonable estimate of the additional short-interval planning labor cost is $230,000 to $280,000.

An additional $10,000 to $20,000 is included to develop procedures for adopting quantifiable performance records and personnel recordkeeping procedures to store performance data.

5.2.4 Likely Barriers

The most significant barrier to improving management skills is the industry’s Tayloristic hierarchical organizational structure, which makes it difficult to transfer a
great deal of trust and control from management to the workforce. The value-added activities, for instance short-interval planning, must be done effectively if the project is to be successful. Tier II places these responsibilities upon the foremen and Tier II JCWs, but Tier II is one version of a comprehensive workforce development and management strategy. It is more important that these activities are done effectively than specifically who in the organization performs them.

5.3 INFORMATION TECHNOLOGY UTILIZATION

The use of information technology is expanding at an amazing rate. For instance, webcams are becoming more and more popular on project sites, and they provide benefits including documentation, fraud prevention, claims analysis, and remote security, supervision and monitoring (Angelo 2001). Application service providers such as Constructware™ are gaining in popularity at the project level for collaborative document and information management (AGC 2002).
5.3.1 Requirements from Tier II Metrics

The Project Information Technology Utilization component is shown in Figure 5.7.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Information Access</td>
<td>6.0</td>
<td>All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically.</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information* is not directly accessed by Tier II workers.</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>4.0</td>
<td>Tier II workers have wireless, wearable computers.</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hardware is nearby and shared among crews.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No hardware is available to Tier II workers.</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills.

Figure 5.7: Tier II Project Information Technology Utilization component

Tier II seeks to capitalize on information technology’s ever-growing abilities to connect people by requiring that project information be stored, integrated, continuously updated, and accessed by Tier II JCWs electronically, and that Tier II JCWs have wireless, wearable computers.

The strategic purpose for this component is for the foremen and Tier II JCWs to have the hardware, software, and ability to utilize technology to support short-interval planning. Examples include:

- Tools – Submit requests, check status.
- Information – Review drawing details, construction specifications, material submittals, MSDS, check RFI status.
- Materials – Submit requests, check status, location.
- Equipment – Submit requests, check status.
- Complete and submit forms, including time sheets, RFLs, quantities, permits, support requests (e.g., materials, scaffolding, crane, QC), equipment usage.

It is important to remember that technology is not a solution in and of itself; it simply allows for faster and more accurate access and transfer of the information already in the system. IT is not a substitute for planning and coordination meetings. In the context of Tier II, information technology enhances communication surrounding the short-interval planning process. The importance of the underlying planning process and the accuracy of the data it generates cannot be overstated. Information technology is a valuable enhancement to a sound process. If the process is weak, information technology will just allow faster access and transfer of unreliable information.

5.3.2 Current Industry Status

The average project score for the overall Information Technology Utilization component was 11/100 and the median score was 0/100.

The average project score for the Integrated Information Access element was 0.5/10, and the median was 0/10. The average project score for the Hardware element was 1.8/10, and the median was 0/10.

These are extremely low scores, but it is important to view them in context. The Tier II requirement is that the access and the hardware are present at the Tier II JCW level – in the baseline data collection, the question evaluated access by journey-level craft workers. Tier I requires the same integration and hardware, but at the field supervisor level. The average project score for the overall Information Technology Utilization component of the Tier I metric was 44.8/100 (Brandenburg 2004). While this score
indicates significant room for improvement, it also shows that projects do utilize some integrated information access and hardware, but it is generally not available to journey-level craft workers.

Industry interviews revealed limited current use of handheld computers for tasks such as time keeping and quantity tracking.

5.3.3 Implementation Requirements

The following goals were established to achieve an advanced level of implementation on the example project:

- 3 types of information (schedule, cost, materials, equipment, safety, drawings, and worker skills) are stored, integrated, continuously updated, and accessed by Tier II JCWs.
- 22 key craft crews are each assigned one wireless, wearable computer that the foreman and Tier II JCWs use to access project information from the field.

Table 5.6 summarizes the information technology utilization element scores for the baseline and the goal (maximum = 10):

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Information Access</td>
<td>0.5</td>
<td>0.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Hardware</td>
<td>1.8</td>
<td>0.0</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The following requirements are necessary to increase the baseline Project Information Technology Utilization Component score (maximum = 100) from a mean of 11.1 and a median of 0.0 to the goal of 60.0:
• Integrate 3 types of project information – match the information that is emphasized in the management skills training to support short-interval planning.

• Provide hardware for 22 individuals and training for 64 individuals. Much of this training will be concurrent with the practical application portion of the management skills training described in section 5.2.

The workforce indicated strong receptiveness to the information technology concepts in the Tier II metrics (Castañada-Maza 2002; see also Figure 4.5).

Commercial options for handheld computers designed for field use by the construction industry are becoming more common (Sawyer 2003). Two of the systems described by Sawyer – ShareChive14 and ThinkShare15 – appear to be suitable for use on the example project. Each includes the establishment of an internet-based project server and a lease arrangement for either ruggedized tablet computers or Personal Digital Assistants (PDAs) that are pre-loaded with proprietary document management software. The document management software typically includes specifications, RFIs, change orders, quantity tracking, and daily reports. The hardware has the potential to access any application on the project’s wireless network, however. The cost of these systems and the reliability of the wireless connections vary, but these issues should improve over the next year or two as the technology continues to advance. No significant training is required, as the systems are based on pull-down menus. ThinkShare provides a great deal of flexibility in customizing its pull-down menus to meet the client’s terminology and in configuring its wireless connections; both of these issues are extremely important in order for the system to be adopted and used in the field. Considering the options currently

available, providing one hardware unit to each crew for the example project will keep the IT implementation costs reasonable – in the range of $75,000 to $100,000.

5.3.4 Likely Barriers

Barriers to improving information technology utilization include:

- Integration of information may be technically difficult and expensive.
- Initial network and hardware cost may be significant.
- Questions surrounding the reliability of wireless connections (Sawyer 2003).
- Physical limitations of the technology, including durability, ease of wear, and ease of use. Ease of use can be enhanced through careful selection of the tasks and applications that are most suitable for handheld computers.

5.4 Craft Utilization

There is no doubt that the craft workers are the most valuable assets on a jobsite. The effective utilization of these assets is vital to maximize the value they can produce in terms of project cost and schedule performance. The Craft Utilization component encourages the effective utilization of highly skilled human assets.
5.4.1 Requirements from Tier II Metrics

Figure 5.8 is the Project Craft Utilization component.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key crafts' crews (on avg.) have at least 40% of Tier II workers.</td>
<td>4.0</td>
<td></td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Key crafts' crews (on avg.) have at least 20% of Tier II workers.</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Less than 50% of key crafts' crews have Tier II workers.</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Key crafts' crews (on avg.) have at least 40% multiskilled workers.</td>
<td>2.0</td>
<td></td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Key crafts' crews (on avg.) have at least 20% multiskilled workers.</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Less than 50% of key crafts' crews have multiskilled workers.</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Less than 2.</td>
<td>4.0</td>
<td></td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Equal to 3.</td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Greater than 4.</td>
<td></td>
<td></td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.8: Tier II Project Craft Utilization component

Tier II requires certain proportions of Tier II JCWs and multiskilled workers in the key crafts, and encourages low worker turnover on the project. These goals are interrelated, especially when considering the “core workforce” approach – Tier II JCWs are extremely likely to be multiskilled, and the fact that a multiskilled core individual tends to stay on a project longer will inherently reduce turnover.

5.4.2 Current Industry Status

The average project score for the overall Project Craft Utilization component was 48.8/100 and the median score was 47.5/100.
The average project score for the Crew Mix element (percentage of Tier II JCWs in key craft crews) was 0.5/10, and the median was 0.0/10. The average project score for the Use of Multiskilled Workers element was 3.8/10, and the median was 3.0/10. The average project score for the Turnover element was 9.6/10, and the median was 10.0/10.

Multiskilling has a significant impact on the individual Tier II technical skills score, and the individual Tier II total score as a result. Of the 770 individual baseline data points (foremen and journey-level craft workers), 43 (6 percent) were classified as Tier II workers (scores of 150 or higher). Of those Tier II workers, 88 percent were certified in more than one craft. Table 5.7 shows the distribution of Tier II workers by number of certified crafts:

Table 5.7: Distribution of Tier II Workers by Number of Certified Crafts

<table>
<thead>
<tr>
<th>Certified Crafts</th>
<th>Count</th>
<th>Pct</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>12%</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>21%</td>
</tr>
<tr>
<td>≥3</td>
<td>29</td>
<td>67%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The Tier II scores for the 5 non-multicrafted Tier II workers ranged from 151 to 155 (maximum = 200), with an average of 153.0. The Tier II scores for the 38 multicrafted Tier II workers ranged from 150 to 197, with an average of 166.7.

5.4.3 Implementation Requirements

The following goals were established to achieve an advanced level of implementation on the example project:

- Key craft crews will have (on average) 42 percent Tier II JCWs16.
- Key craft crews will have (on average) 42 percent multiskilled workers17.

16 Calculated as 42 Tier II JCWs ÷ 99 average (JCWs and Helpers) in the key crafts.
17
Worker turnover will be 2.2\textsuperscript{18}.

Table 5.8 summarizes the project craft utilization element scores for the baseline and the goal (maximum = 10):

Table 5.8: Project Craft Utilization Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Mix</td>
<td>0.5</td>
<td>0.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Use of Multiskilled Workers</td>
<td>3.8</td>
<td>3.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Worker Turnover</td>
<td>9.6</td>
<td>10.0</td>
<td>9.0</td>
</tr>
</tbody>
</table>

The workforce is less receptive to improvement in this component than in any other area of Tier II (Castañada-Maza 2002; see also Figure 4.3). Detailed responses regarding receptiveness to the multiskilling concepts in the Tier II metrics are provided in Figure 4.6. Anecdotally, this was predominantly due to pride in an individual’s craft, but clearer definitions of what constitutes multiskilling may address some of these concerns.

The workforce development efforts described in sections 5.1 through 5.3 are sufficient to increase the baseline Project Craft Utilization Component score from a mean of 48.8 and a median of 47.5 to a goal of 96.0.

5.4.4 Likely Barriers

Barriers to improving craft utilization include:

- The cost and time required to develop and maintain significant numbers of multiskilled and Tier II JCWs, including continuous training and higher wages.

\textsuperscript{17} All of the Tier II JCWs will be multiskilled through the technical training requirement (section 5.1).

\textsuperscript{18} Calculated as 675 ÷ 306. Data from Table 4.2.
- The tendency for companies to maximize current production at the expense of long term value. Multiskilled individuals require different work assignments in order to maintain their skills in those areas.
- Tier II creates additional “categories” of personnel (Tier II JCWs and multiskilled workers), which adds complexity to the task of assigning and managing personnel.

5.5 ORGANIZATION

The organization is the structure in which the human assets operate. Sections 5.1 through 5.4 describe the development of individuals’ technical and management skills, the use of information technology to enhance performance, and the distribution of highly skilled individuals in the key crafts. The project organization component is somewhat of a broader context – the Tier II approach to organization contains elements dealing with communication and autonomy.
5.5.1 Requirements from Tier II Metrics

Figure 5.9 is the Project Organization index, which evaluates the communication and delegation of authority on the project.

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weight</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Max Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>6.0</td>
<td>Proactive information flow to and from workers about the project, established formal &amp; informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project. Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy. Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.</td>
<td>10</td>
<td>60</td>
</tr>
<tr>
<td>High Performance Work Place</td>
<td>4.0</td>
<td>Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management skills and IT information available thru Tier II workers. Hierarchical structure, but with 2-way information &amp; idea flow between crews and management. Rigid hierarchical structure.</td>
<td>10</td>
<td>40</td>
</tr>
</tbody>
</table>

Figure 5.9: Tier II Project Organization component

Tier II requires proactive communication between management and crews, and encourages a “high performance” organizational structure.

It is important to remember that there are a number of different forms of “high performance” organizations. Tier II work teams can exist in a number of different forms – recall the discussion of supervised, self-directed, and autonomous teams in section 2.4.5
(CSHR 1994). The key to effective implementation is to tailor the approach to the situation.

5.5.2 Current Industry Status

The average project score for the overall Organization component was 50.3/100 and the median score was 53.4/100.

The average project score for the Communication element was 5.4/10, and the median was 5.8/10. The average project score for the High Performance Work Place element was 4.8/10, and the median was 5.0/10.

5.5.3 Implementation Requirements

The following goals were established to achieve an advanced level of implementation on the example project:

- A communications structure characterized by proactive information flow between crews and management through regular channels and meetings.
- A hierarchical organizational structure, but with delegation of authority and accountability to supervised Tier II work teams as appropriate. Tier II JCWs effectively utilize their management skills and information technology to support and plan for their crews.

Table 5.9 summarizes the project organization element scores for the baseline and the goal (maximum = 10):

Table 5.9: Project Organization Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication</td>
<td>5.4</td>
<td>5.8</td>
<td>7.5</td>
</tr>
<tr>
<td>High Performance Work Place</td>
<td>4.8</td>
<td>5.0</td>
<td>6.0</td>
</tr>
</tbody>
</table>
The following requirements are necessary to increase the baseline Project Organization Component score (maximum = 100) from a mean of 50.3 and a median of 53.4 to the goal of 69.0:

- Training in the areas of communications and work teams.
- Changes in communication policies.
- Tier II JCW management and IT skills that support these goals are addressed in sections 5.2 and 5.3.

The workforce is generally very receptive to improvement in this area (Castañada-Maza 2002; see also Figure 4.7).

The contractor implementing high performance work teams presented in section 2.4.5 spent $17,000 in direct training costs, not including craft wages (Chapman and Gerson 1999). Two to three days of training for Tier II workers, plus facilitation costs, are estimated at $50,000 to $75,000.

This is likely the most difficult change to make in the Tier II strategy, because it is a fundamental organizational and/or cultural change. Construction historically employs a hierarchical command and control structure because it is effective in managing large numbers of people.

Lessons learned from previous attempts to use work teams in construction include the specific consideration of work teams when planning the project, the development and use of a multicraft wage scale and training plan, and the development of a comprehensive data measurement system in order to measure benefits (Chapman and Gerson 1999).

Communication will likely improve somewhat naturally as a result of the structured short-interval planning process, including participation in coordination meetings, providing status reports on critical work assignments, etc.
5.5.4 Likely Barriers

Barriers to improving organization include:

- The cultural change regarding changes in communication. There is frequently a reluctance to share project information, such as schedule, cost, and productivity targets and performance, with foremen and journey-level craft workers, but this is a logical prerequisite to providing electronic access to this information from the field as described in the IT Utilization component.

- The cultural change regarding the use of work teams. This can represent a “significant change from the traditional way construction work and supervision has been handled...many in the industry have predicted that the change to work teams would not be readily accepted.” (Chapman and Gerson 1999).

- The elements of successful Tier II work teams (e.g., teamwork, communication, trust) take time to develop.

- Not every individual will work well in a work team environment (Chapman and Gerson 1999). This barrier may be seen in supervisors more frequently than in crew members, as modern society generally appears to favor a team approach.

5.6 SUMMARY

This chapter presented the current status of the industry based on the Tier II metrics (the Tier II Baseline) for each component and each element, identified the requirements and estimated costs to implement Tier II at an advanced level for the CII Model Plant, and noted the barriers that are likely to be encountered.
Table 5.10 summarizes the individual scores for the baseline and the goal for Tier II individuals. The maximum score for each component is 100, and individuals must score ≥150 points to be considered a “Tier II worker”:

Table 5.10: Tier II Individual Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Technical Skills</td>
<td>64</td>
<td>52</td>
<td>80</td>
</tr>
<tr>
<td>Individual Management Skills</td>
<td>43</td>
<td>41</td>
<td>87</td>
</tr>
<tr>
<td><strong>Individual Tier II Score</strong></td>
<td><strong>107</strong></td>
<td><strong>93</strong></td>
<td><strong>167</strong></td>
</tr>
</tbody>
</table>

Table 5.11 summarizes the project scores for the baseline and the goal. The maximum score for each component is 100, and the maximum overall project score is 10.

Table 5.11: Tier II Project Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Craft Technical Skills</td>
<td>38.0</td>
<td>33.8</td>
<td>85.0</td>
</tr>
<tr>
<td>Project Craft Management Skills</td>
<td>44.0</td>
<td>38.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Information Technology Utilization</td>
<td>11.1</td>
<td>0.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Craft Utilization</td>
<td>48.8</td>
<td>47.5</td>
<td>96.0</td>
</tr>
<tr>
<td>Organization</td>
<td>50.3</td>
<td>53.4</td>
<td>69.0</td>
</tr>
<tr>
<td><strong>Tier II Project Index</strong></td>
<td><strong>3.8</strong></td>
<td><strong>3.5</strong></td>
<td><strong>8.2</strong></td>
</tr>
</tbody>
</table>

The implementation requirements identified in this chapter result in a Tier II Project Index of 8.2/10 for the example project.

The baseline data indicate that the industry provides very little continuous training to foremen and journey-level craft workers, regardless of their tenure with the same company. The median amount of training reported in the last three years was 24 hours. Approximately 60 percent of respondents reported no training in their careers on the subjects of planning and job management skills.
More than half of the respondents claimed proficiency in at least one of the five administrative skills identified in the metrics, with material management being the most common. More than half also claimed proficiency in at least one of the seven computer skills identified in the metrics; email/internet was the most common, and was mentioned more than twice as frequently as the next most common response.

The baseline data indicate a significant amount of multicrafting within the six key crafts for the Model Plant example project, although these data do not necessarily represent a “certified plus” level of proficiency.

It is important to realize that the barriers noted are summarized from a historical perspective. Many of the barriers (e.g., lost investment due to turnover) will likely be overcome through the process of implementing Tier II (for example, investing in core employees, paying higher wages for higher skills, and managing a project well through effective short-interval planning all work together to reduce the likelihood of turnover). The barriers are presented primarily to inform the reader of commonly-stated objections to change. They provide an outline of factors to address when developing a detailed implementation plan.
Chapter 6: Expected Benefits

The dissertation changes focus in this chapter, which presents the expected benefits of achieving an advanced level of Tier II implementation on the CII Model Plant. The process of identifying and quantifying the expected benefits follows the guidance from the literature as presented in section 2.6.2; that is, quantify what is possible, then estimate, and identify other impacts for qualitative consideration – and be conservative.

6.1 Identification of Benefits

It is difficult to produce solid figures that prove a certain return on investment for training and other human resource development programs in the construction industry. An ideal solution would be for contractors to use their unit rates or unit cost metrics to measure improvement and convince owners of the benefits. However, the effects of human resource development programs are not isolated, there is rarely a control group, and the impacts of change are not achieved uniformly. It is possible to collect data during the pre-existing condition, and again after a change in procedure, and compare the two. Any difference cannot be wholly attributed to the change, but in the end, it is the results that count. This chapter presents the expected benefits of Tier II implementation, based on available published and unpublished data, some of which was estimated in the manner just described.

It is valuable to review the original goals and characteristics of the Tier II strategy presented in section 1.1 (Borcherding, et al. 2001):

- Similar or lower project construction costs,
- Better safety, quality, productivity, and schedule performance,
- More predictability and less chaos due to effective crew-level planning and scheduling,
- Better worker craft skills, including multiskilled/multicrafted workers,
- Higher hourly compensation,
- More crew autonomy and less administration and supervision,
- Fewer total hires and less turnover on a project,
- Higher loyalty between workers, the project, and the employers, and
- Less attrition in the industry due to defined career path opportunities.

Regarding the technical skills portion of Tier II, the NCCER Accreditation Guidelines claim that training increases productivity, which in turn increases profitability, reduces absenteeism and turnover, and increases client satisfaction, which ultimately increases the potential for future business. The goal of the accreditation program is to produce “[w]ell-trained workers are more capable of identifying potential problems and making innovative, cost-reducing solutions.” (NCCER 2003a).

CCIS has identified and estimated the benefits of multiskilling. These include increased individual employment duration, increased individual earnings, more challenging work, greater understanding of the work process, higher motivation, reduction in idle time, productivity improvement, reduction in required labor force, decreased labor costs, and decreased project costs (Burleson 1997, Carley 1999).

With respect to the management skills portion of Tier II, CICE observed that better planning leads to better productivity, which can lead to other benefits, including reduced overtime, better safety, less absenteeism, and reduced labor cost (BRT 1983). CICE also documented a case study of supervisor training: “the savings resulting from improved productivity were several times the cost of the training. Other probable benefits to the owner’s project include better schedules, improved safety and quality, and reduced turnover and absenteeism.” (BRT 1982b).
These benefits are divided into two broad categories: those that can be quantified or estimated, and those that cannot.

Project-level benefits that can be quantified or estimated include:

- Improved productivity,
- Improved safety,
- Decreased absenteeism,
- Decreased turnover, and
- Decreased rework.

There are two project-level benefits that could be quantified for an actual implementation, but are not quantified in this example:

- Decrease in required overtime. Productivity losses and increased safety risks due to extended overtime are well-documented. The CII Model Plant staffing example assumed a 40-hour work week, however, so this benefit is not applicable to the example project.

- Increased span of control of field supervisors. As the implementation matures, perhaps over several projects, it is reasonable to assume that field supervisors may be able to manage a wider span of control, depending on the skills of the available Tier II JCWs and the use of Tier II work teams. It is possible that at some point this would generate quantifiable savings in terms of a reduction in field supervision for a project.

Project-level benefits that are listed for qualitative consideration:

- Increase in instructors’ knowledge by teaching,
- Increase in supervisor’s knowledge about their crew members,
- Increase in motivation and satisfaction,
- Better overall attitudes,
- Positive peer pressure to improve individual skills and performance, and
- Increase in customer satisfaction due to better performance.

This dissertation has a project-level perspective. However, it is beneficial to note that Tier II will create individual benefits as well. Individual-level benefits that can be quantified or estimated include an increase in length of employment on a given project and increased earnings due to improved skills and longer employment. Individual-level benefits that are more difficult to quantify include increased motivation and satisfaction, better overall attitude, positive peer pressure to improve skills and performance, more challenging work, and an increased understanding of the work process.

6.2 IMPROVED PRODUCTIVITY

Two commonly used methods to assess construction productivity are the Work Sampling (WS) method and the Foreman Delay Survey (FDS) method.

Oglesby, Parker, and Howell (1989) wrote a popular textbook on the subject of construction productivity that describes the work sampling method. Craft time is divided into three major classifications: effective work, essential contributory work, and ineffective work. An in-depth study described in the textbook yielded average percentages for “good [project] performance” of 36 percent effective work, 33 percent essential contributory work, and 31 percent ineffective work. A metric called the Labor Utilization Factor (LUF) adds 25 percent of the essential contributory work to the effective work to reflect a more accurate estimate of “productive” time. The LUF for the study mentioned above is 44 percent. “Continuous work-sampling is a demonstrated, cost-effective method of obtaining statistical labor use data in labor-intensive environments such as outage construction projects.” (Picard and Seay 1996). Figure 6.1 illustrates a breakdown of craft time using this approach.
The Foreman Delay Survey method is based on the responses to hundreds of foreman delay surveys that have been completed over the last two decades. Figure 6.2 illustrates a typical distribution for a heavy industrial project. The productive time category relates to the direct work category in the work sampling method. The other categories define different causes of inefficiency. Administrative delays are normally the focus of productivity improvement programs. An effective short-interval planning process can significantly reduce administrative delays (Pappas, Tucker, and Borcherding 2003). “Jurisdiction” does not imply union jurisdictional issues, but rather the

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20 Administrative delays are caused by problems with tools, information, materials, equipment, crew interference, etc.
inefficiencies within and between crews and crafts. Methods and personal time are additional causes of inefficiency and delay.

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td>Administrative Delays</td>
</tr>
<tr>
<td>10%</td>
<td>Personal</td>
</tr>
<tr>
<td>15%</td>
<td>Methods</td>
</tr>
<tr>
<td>15%</td>
<td>Jurisdiction</td>
</tr>
<tr>
<td>40%</td>
<td>Productive Time</td>
</tr>
</tbody>
</table>

Figure 6.2: Craft Time Breakdown – Foreman Delay Survey Method

Meyer (1989), Simonson (1989), and Petersen (1990) reported the results of an extremely detailed study of construction craft productive time. They recorded individual crew members’ activities on a minute-by-minute basis during 616 directly observed electrical, pipe, and structural iron work hours on 5 projects. These crafts comprise the majority of the work in the CII Model Plant, and combining the data from this study results in an average of 39 percent productive time. Their detailed records also provide some insight into intra-crew inefficiencies that are categorized as “Jurisdiction” on the Foreman Delay Survey.

The net effect of implementing a workforce development and management program such as Tier II is improved productivity. Two unpublished case studies (Gulf
Coast projects between 2001 and 2003) indicated the significant impact of technical craft training alone on productivity. A maintenance site with more than 100 workers experienced an increase in productivity coinciding with an increase in the percent of craft workers passing the written certification test. Over an eight month period, the percent passing the written test increased from 65 percent to 73 percent, while the productivity factor increased from 0.85 to 1.10 – an increase of 29 percent. The second case, a 125,000 work hour construction project, spent less than $25,000 on craft training, and conservatively estimated a savings of 10 percent of the estimated work hours. At a pay rate of $20 per hour, this translated to a return of $250,000, or 10 times the investment.

Hickok (2003) analyzed data from 84 craft worker questionnaire survey summary reports, representing 909 individual surveys from 42 projects in the United States between 1990 and 2003. Of these, 28 reports represented responses from 65 electricians and 341 pipe fitters on industrial projects, and thus are particularly applicable to this dissertation. The average amount of lost time on those industrial projects was 34 percent. The most significant cause of lost time was problems with materials (29 percent), followed by tools (15 percent), design interpretation (14 percent), equipment (12 percent), overcrowding (11 percent), crew interference (10 percent), and instructions (9 percent) – all delays that short-interval planning is designed to prevent. Five of the 42 projects implemented active productivity improvement programs, and these projects reduced their lost time in half. This is a small sample, but indicates that the proactive management of providing resources to the crews can have a significant impact on lost time, and as a result, on project performance.

Tucker, et al. (1980) documented a reduction in administrative delays from 22 percent to 13.3 percent in only three months due to a concentrated productivity improvement program.
Picard (1998) stated, “Experience on hundreds of in-plant construction projects has shown that productive use of available labor-hours is 50 percent or less. Early improvement of the work process can increase this to 60 to 70 percent, and subsequently to a lean 80 percent.” Picard and Seay (1996) documented TVA’s “[o]verall workhour savings of 20% and greater…since the start of implementing the continuous improvement process,” as well as a 34 percent increase (from 50 percent to 67 percent) in average productive time on 42 industrial outage projects over a 2.5-year period.

Using the Work Sampling method, the effective implementation of Tier II will decrease support work and especially delays, and increase direct work. It is reasonable to expect a Labor Utilization Factor in the range of 60 to 70 percent. The expected savings for the example project are shown in Table 6.1:

Table 6.1: CII Model Plant Savings Due to Increased Productivity – Based on Work Sampling Method

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Advanced Level of Tier II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned direct labor (DL) work hours</td>
<td>485,000</td>
<td>485,000</td>
</tr>
<tr>
<td>Labor Utilization Factor</td>
<td>44%</td>
<td>60%</td>
</tr>
<tr>
<td>Non-productive work hours</td>
<td>271,600</td>
<td>194,000</td>
</tr>
<tr>
<td>Actual direct labor work hours</td>
<td>485,000</td>
<td>407,400</td>
</tr>
<tr>
<td>Percentage of DL hours saved</td>
<td>0%</td>
<td>16%</td>
</tr>
<tr>
<td>Actual direct labor cost</td>
<td>$13,177,000</td>
<td>$11,069,000</td>
</tr>
<tr>
<td>Savings due to Increased Productivity</td>
<td>$2,108,000</td>
<td>$3,426,000</td>
</tr>
</tbody>
</table>

Using the Foreman Delay Survey method, the effective short-interval planning inherent in Tier II will reduce administrative delays and inefficiency due to methods. The multicrafting inherent in Tier II will reduce inefficiency due to jurisdictional issues. Numerous case studies document reductions in delays of approximately 50 percent; it is reasonable to expect that these three sources of delay would be reduced from a combined
50 percent \((20 + 15 + 15)\) to a range of 25 to 30 percent. The expected savings for the example project are shown in Table 6.2:

Table 6.2:  CII Model Plant Savings Due to Increased Productivity – Based on Foreman Delay Survey Method

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Advanced Level of Tier II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned direct labor (DL) work hours</td>
<td>485,000</td>
<td>485,000 - 485,000</td>
</tr>
<tr>
<td>Administrative Delays</td>
<td>20%</td>
<td>10% - 10%</td>
</tr>
<tr>
<td>Inefficiency - Jurisdiction &amp; Methods</td>
<td>30%</td>
<td>20% - 15%</td>
</tr>
<tr>
<td>Non-productive work hours</td>
<td>242,500</td>
<td>145,500 - 121,250</td>
</tr>
<tr>
<td>Actual direct labor work hours</td>
<td>485,000</td>
<td>388,000 - 363,750</td>
</tr>
<tr>
<td>Percentage of DL hours saved</td>
<td>0%</td>
<td>20% - 25%</td>
</tr>
<tr>
<td>Actual direct labor cost</td>
<td>$13,177,000</td>
<td>$10,541,000 - $9,883,000</td>
</tr>
</tbody>
</table>

**Savings due to Increased Productivity**  
**Baseline**  **Advanced Level of Tier II**  **$2,636,000**  **$3,294,000**

One might question the fact that this estimate includes productivity gains across the entire workforce, while Tier II concentrates on key crafts. This question is valid, but the methodology used is sound. The impacts of Tier II, especially with respect to better planning and improved coordination between crews, will benefit much more than just the key crafts. Productivity improvement programs rarely involve all personnel on a project, but the benefits are achieved beyond the direct scope of the application (Tucker, et al. 1980).

6.3  IMPROVED SAFETY

Two unpublished case studies (Gulf Coast projects between 2001 and 2003) reported that as craft certifications increased, the number of first aid and recordable cases dropped dramatically. One contractor cited a 78 percent reduction in the combined number of incidents, and the other improved from 54 first aid cases and 3 recordable incidents in one year to 2 first aid cases and 2 recordable incidents 4 years later.
The financial quantification of safety incidents was an effective catalyst in the industry’s efforts to improve safety in the 1990s. CII (1993) estimated the cost of a recordable incident at $1,100. Shields (2002) used a value of $200,000 for a lost workday case incident.

CII companies have significantly better safety records than the construction industry as a whole. The average recordable incident rate for CII companies in 2001 was 1.02, compared to 7.28 for the entire industry (Tuchman 2003). The lost workday case incident rate is a small fraction of the recordable rate.

Assuming average CII safety performance for the example, a recordable incident rate of 1.02 for the CII Model Plant would yield 2.5 recordable incidents. The maximum potential financial benefit due to improved safety for the example project would then be $2,750. While safety is always a top priority, this financial benefit will not be considered in this particular example.

6.4 DECREASED ABSENTEEISM

CICE quantified the effect of absenteeism in its summary report: “On large projects during periods of high labor demand, absenteeism as high as 20% and annual turnover reaching 200% were reported. If these levels could be cut in half – a reasonable goal – labor-cost savings would range from 5% to 10%.” (BRT 1983).

Human resource development expert Jack Phillips (1991) estimated that each occurrence of absenteeism cost $80 to $100, which, when updated using the Consumer Price Index, is $108 to $135.

The construction implementation of high performance work teams described in section 2.4.5 achieved an absenteeism rate that was 68 percent lower than expected (Chapman and Gerson 1999).
Three unpublished case studies (domestic projects between 2001 and 2003) yielded the following results:

- One contractor recorded the difference in absenteeism rates between “certified plus” journey-level craft workers and the rest of the project workforce. Over a full year, the certified plus group averaged a 6 percent absenteeism rate compared to 12 percent for the rest of the workforce. In any given month, the certified plus group’s absenteeism rate was at least 3 percentage points less than the other rest of the workforce.

- Another contractor experienced a 50 percent drop (from 1.2 percent to 0.6 percent) in unexcused absences over three years, coinciding with an increase in craft certifications.

- The third case study recorded absenteeism rates for 1,000 workers on 5 projects over a 15 month period of time. Those attending training courses averaged a 0.7 percent absenteeism rate, compared to 7 percent for those not in training.

We will assume a reduction in the absenteeism rate from 8 percent down to 4 to 5 percent, and a cost of $110 per occurrence. This is significantly more conservative than the Business Roundtable formula that indicates a 1.5 percent savings in total labor cost for each 1 percent reduction in absenteeism, which would produce a savings of approximately 3 times the estimate used here. The expected savings for the example project are shown in Table 6.3:
Table 6.3: CII Model Plant Savings Due to Decreased Absenteeism

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Advanced Level of Tier II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Duration (days)</td>
<td>312</td>
<td>312</td>
</tr>
<tr>
<td>Absenteeism Rate</td>
<td>8%</td>
<td>5%</td>
</tr>
<tr>
<td>Average Manpower(^21)</td>
<td>155</td>
<td>155</td>
</tr>
<tr>
<td>Absentees per Day</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>Unit Cost of Absenteeism</td>
<td>$110</td>
<td>$110</td>
</tr>
<tr>
<td>Total Cost of Absenteeism</td>
<td>$425,000</td>
<td>$265,000</td>
</tr>
<tr>
<td><strong>Savings due to Decreased Absenteeism</strong></td>
<td><strong>$160,000</strong></td>
<td><strong>$213,000</strong></td>
</tr>
</tbody>
</table>

6.5 DECREASED TURNOVER

CII found that companies with turnover rates (the percentage of total hires that quit or were terminated for cause) of less than 20 percent experienced better productivity, better safety, completed projects on or ahead of schedule, and made profits on more projects than those with rates greater than 20 percent (CII 1999).

The construction implementation of high performance work teams described in section 2.4.5 achieved a turnover rate that was 34 percent lower than expected (Chapman and Gerson 1999).

An unpublished contractor case study recorded turnover rates for 1,000 workers on 5 domestic projects over a 15 month period of time. Those attending training courses and in a special recognition program\(^22\) averaged 0.5 percent turnover, compared to 6 percent for those not in training or the recognition program.

One of the most significant factors affecting turnover is the local economic situation. If jobs are plentiful, workers are more likely to leave a project, especially for

\(^{21}\) Calculated as 485,000 DL hours ÷ 78 weeks ÷ 40 hours per week.

\(^{22}\) Craft workers were selected for this program based on performance on written and skills tests, and a review by an evaluation board.
more pay, whether due to a higher wage rate, more per diem, or more overtime. Turnover is generally less when construction jobs in the area are scarce.

Job dissatisfaction is another significant cause of turnover, and poor job management is a significant cause of dissatisfaction (BRT 1982a). An effective short-interval planning and management system can have a tremendous positive impact on dissatisfaction and turnover (Borcherding and Oglesby 1974, Borcherding and Oglesby 1975, BRT 1983, Picard 1998, Bernstein 2003).

CICE estimated that the cost of turnover was equivalent to 24 hours of labor per occurrence (BRT 1982a). Although this is a well-known estimate, it was made more than twenty years ago, and CII has since stated that this estimate does not include current requirements for additional safety training or new employee orientation, the administrative costs of hiring and firing, or the additional safety risk posed by new hires (CII 1999). It also does not consider the loss of learning curve improvements gained by the lost worker; for example, a project replacing a worker who has spent six weeks making terminations in a motor control center will generally experience a significant decrease in production from a replacement worker who is new to the situation.

CII found that “a 10 percent increase in turnover rate added about a 2.5 percent increase to labor costs, assuming turnover is constant throughout the project” (CII 2000). The same study also found “that an increasing turnover rate results in a decline in the productivity factor.”

One contractor values each turnover case at approximately $2,700. Information from Helmets to Hardhats indicates that hiring costs alone approach $2,400 (H2H 2004, Winston and Loweis 2004).
We will assume a reduction in turnover rate from 15 percent down to 5 to 10 percent, and a cost of $2,500 per occurrence. The expected savings for the example project are shown in Table 6.4:

Table 6.4: CII Model Plant Savings Due to Decreased Turnover

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Advanced Level of Tier II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turnover Rate</td>
<td>15%</td>
<td>10% - 5%</td>
</tr>
<tr>
<td>Total Hires</td>
<td>675</td>
<td>675 - 675</td>
</tr>
<tr>
<td>Workers Lost to Turnover</td>
<td>101</td>
<td>68 - 34</td>
</tr>
<tr>
<td>Unit Cost of Turnover</td>
<td>$2,500</td>
<td>$2,500 - $2,500</td>
</tr>
<tr>
<td>Total Cost of Turnover</td>
<td>$253,000</td>
<td>$168,000 - $84,000</td>
</tr>
<tr>
<td>Savings due to Decreased Turnover</td>
<td>$85,000 - $169,000</td>
<td></td>
</tr>
</tbody>
</table>

6.6 **DECREASED REWORK.**

Decreased rework is certainly expected as a result of Tier II. Rework due to craft errors is included in the “Administrative Delays” portion of the productivity calculation, so no further calculation is needed.

6.7 **SUMMARY**

This chapter outlined the assumptions and calculations used to estimate the value of the project benefits that are expected due to advanced implementation of Tier II on the CII Model Plant. The estimates are conservatively low, and are presented as ranges to reflect the inherent variability in the process.
Chapter 7: Evaluation of Benefits and Costs

This chapter summarizes the benefits (presented in Chapter Six) and the costs (presented in Chapter Five) of achieving an advanced level of Tier II implementation on the CII Model Plant as an example project, and calculates benefit-cost ratios for consideration.

7.1 Summary of Benefits

The expected benefits identified in Chapter Six are summarized below:

Table 7.1: Tier II Implementation Benefits for CII Model Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Project Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings due to Increased Productivity – WS method</td>
<td>$2,108,000 - $3,426,000</td>
</tr>
<tr>
<td>Savings due to Increased Productivity – FDS method</td>
<td>$2,636,000 - $3,294,000</td>
</tr>
<tr>
<td>Savings due to Decreased Absenteeism</td>
<td>$160,000 - $213,000</td>
</tr>
<tr>
<td>Savings due to Decreased Turnover</td>
<td>$85,000 - $169,000</td>
</tr>
<tr>
<td><strong>Total Expected Benefits</strong></td>
<td><strong>$2,881,000 - $3,676,000</strong></td>
</tr>
</tbody>
</table>

Due to its tighter range, the Foreman Delay Survey method for calculating productivity is used for the expected savings due to improved productivity. The mean using the Work Sampling method is $2.77 million, which is within the range of the FDS calculation.

The total expected benefit from the proposed implementation of Tier II on the CII Model Plant example project is $2.88 to $3.67 million.

7.2 Summary of Costs

The implementation costs were identified in Chapter Five. One of the goals of Tier II is to provide higher wages for highly-skilled craft workers (Borcherding, et al.)
Assuming that the project begins with approximately 32 Tier II workers and ramps up to the maximum of 64 Tier II workers, a Tier II premium of $1 per hour adds almost $150,000 to the cost of the program. The amount of the premium is based on feedback from the 21 experienced craft-level industry professionals who participated in the July 2001 CCIS metrics development workshop, and the fact that the wage data in the CCIS workforce database indicate that the difference in pay between foremen and journey-level craft workers is $2.00 per hour (difference in medians) to $2.50 per hour (difference in means). The costs of the program are summarized below.

Table 7.2: Tier II Implementation Costs for the CII Model Plant

<table>
<thead>
<tr>
<th>Description</th>
<th>Qty</th>
<th>Unit Cost</th>
<th>Project Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craft Training and Certification</td>
<td>64</td>
<td>$2,000 -  $5,000</td>
<td>$128,000 -  $320,000</td>
</tr>
<tr>
<td>On-Site Training Coordinator</td>
<td>78</td>
<td>$1,236 -  $1,236</td>
<td>$96,500 -  $96,500</td>
</tr>
<tr>
<td>Management Skills Training</td>
<td>64</td>
<td>$2,000 -  $3,500</td>
<td>$128,000 -  $224,000</td>
</tr>
<tr>
<td>Short-Interval Planning Consultant</td>
<td>LS</td>
<td>$50,000 -  $50,000</td>
<td>$50,000 -  $50,000</td>
</tr>
<tr>
<td>Short-Interval Planning OT</td>
<td>LS</td>
<td>$230,000 -  $280,000</td>
<td>$230,000 -  $280,000</td>
</tr>
<tr>
<td>Performance Record</td>
<td>LS</td>
<td>$10,000 -  $20,000</td>
<td>$10,000 -  $20,000</td>
</tr>
<tr>
<td>Information Technology</td>
<td>LS</td>
<td>$75,000 -  $100,000</td>
<td>$75,000 -  $100,000</td>
</tr>
<tr>
<td>Organization</td>
<td>LS</td>
<td>$50,000 -  $75,000</td>
<td>$50,000 -  $75,000</td>
</tr>
<tr>
<td>Tier II Premium Pay</td>
<td>LS</td>
<td>$150,000 - $150,000</td>
<td>$150,000 -  $150,000</td>
</tr>
<tr>
<td><strong>Total Expected Costs</strong> (rounded up)</td>
<td></td>
<td></td>
<td><strong>$918,000 -  $1,316,000</strong></td>
</tr>
</tbody>
</table>

The total expected program cost of the proposed implementation of Tier II on the CII Model Plant example project is $0.92 to $1.32 million.

7.3 **Benefit-Cost Ratio**

The benefits and costs are presented as ranges to reflect the inherent variability in the process. A range of benefit-cost (B/C) ratios can be calculated based on these
estimates, in order to indicate the expected return on investment for the proposed implementation of Tier II:

Table 7.3: Benefit-Cost Ratios for the CII Model Plant

<table>
<thead>
<tr>
<th></th>
<th>Benefit</th>
<th>Cost</th>
<th>B/C Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Estimate</td>
<td>$2,881,000</td>
<td>$918,000</td>
<td>3.1:1</td>
</tr>
<tr>
<td>Mean</td>
<td>$3,278,500</td>
<td>$1,117,500</td>
<td>2.9:1</td>
</tr>
<tr>
<td>High Estimate</td>
<td>$3,676,000</td>
<td>$1,316,000</td>
<td>2.8:1</td>
</tr>
</tbody>
</table>

A very conservative B/C ratio can be calculated using the low benefit estimate and the high cost estimate: $2.88 million ÷ $1.32 million = 2.2:1.

These ratios appear conservative, based on claimed B/C ratios for construction training and productivity improvement programs:

- A productivity improvement program on a large petrochemical project yielded a B/C ratio of 16 to 1 (Tucker, et al. 1980).
- An unpublished contractor case study of 1,500 people on 4 domestic projects between 2001 and 2003 reported a return of 2 to 1.
- “A CICE study team concludes that owners who support contractors’ training programs for foremen and general foremen can reasonably expect a return on that investment of ‘at least three to one’.” (BRT 1983).
- CII cited a 1994 CIWF study that estimated the “return on investment for contractor training in general at 2 to 1, with a range of 1.1 to 1 to 3 to 1 (Liska, 1994).” (CII 1996b).

This example assumed that the full costs and benefits were incurred during the example project, in order to provide a consistent evaluation. It is expected that the first attempt at implementation would experience the majority of the costs and only part of the benefits, and that later projects would incur significantly decreased costs (as most of the
then-trained Tier II workforce is retained as core employees) while generating significantly increased benefits. If one assumes that this example is a first attempt to implement Tier II, and that the first project would experience the full costs but only half of the benefits, the resulting B/C ratio is still approximately 1.5:1, which is very favorable given the fact that the investment precedes the improvement.

7.4 SUMMARY

Comparisons of comparable cost estimates yield benefit-cost ratios of approximately 3:1 for an advanced level of Tier II implementation on the CII Model Plant. An extremely conservative B/C ratio is 2.2:1. This information should assist companies interested in workforce development to evaluate implementation of the Tier II strategy on a pilot project.
Chapter 8: Conclusions and Recommendations

8.1 Review of Objectives and Conclusions

The Tier II strategy emphasizes the development of a highly-skilled core within the journey-level construction workforce. The three primary objectives of this dissertation are reviewed here:

1. *Determine the current status of the construction industry based on the Tier II metrics.* Chapter Four presented the Tier II Baseline in terms of the Project Index (mean = 3.8 on a scale of 1 to 10) and the five project components. Chapter Five presented a more detailed analysis, in terms of the individual metrics and the elements constituting each of the five project components.

2. *Provide quantitative guidance regarding the implementation of the Tier II strategy for an example project.* Chapter Four described the process used to determine that 64 Tier II individuals (foremen and journey-level craft workers) are required for the CII Model Plant key crafts, and Chapter Five described the activities and costs required to implement Tier II on the CII Model Plant in order to achieve a Tier II Project Index score of 8.2 on a scale of 1 to 10.

3. *Evaluate the expected benefits and costs of achieving an advanced level of Tier II implementation for an example project.* Chapters Five and Six provided detailed cost and benefit estimates, respectively, for the implementation example. These estimates were summarized in Chapter Seven, and resulted in a minimum expected benefit-cost ratio in the range of 2.2:1 to 3.1:1.
The following conclusions are supported:

- Based on the Tier II metrics, the CCIS baseline data, published literature, and unpublished industry data gathered through interviews and meetings, the requirements to implement the Tier II at an advanced level can be quantified, and the minimum expected benefit-cost ratio is in the range of 2.2:1 to 3.1:1. The hypothesis is confirmed.

- The baseline data indicate that the industry exhibits widely varying performance and significant room for improvement. Tables 8.1 and 8.2 review the baseline and the goals for the Tier II individual and project metrics, respectively:

Table 8.1: Tier II Individual Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Technical Skills</td>
<td>64</td>
<td>52</td>
<td>80</td>
</tr>
<tr>
<td>Individual Management Skills</td>
<td>43</td>
<td>41</td>
<td>87</td>
</tr>
<tr>
<td><strong>Individual Tier II Score</strong></td>
<td><strong>107</strong></td>
<td><strong>93</strong></td>
<td><strong>167</strong></td>
</tr>
</tbody>
</table>

Table 8.2: Tier II Project Scores

<table>
<thead>
<tr>
<th>Element</th>
<th>Baseline (Mean)</th>
<th>Baseline (Median)</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Craft Technical Skills</td>
<td>38.0</td>
<td>33.8</td>
<td>85.0</td>
</tr>
<tr>
<td>Project Craft Management Skills</td>
<td>44.0</td>
<td>38.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Information Technology Utilization</td>
<td>11.1</td>
<td>0.0</td>
<td>60.0</td>
</tr>
<tr>
<td>Craft Utilization</td>
<td>48.8</td>
<td>47.5</td>
<td>96.0</td>
</tr>
<tr>
<td>Organization</td>
<td>50.3</td>
<td>53.4</td>
<td>69.0</td>
</tr>
<tr>
<td><strong>Tier II Project Index</strong></td>
<td><strong>3.8</strong></td>
<td><strong>3.5</strong></td>
<td><strong>8.2</strong></td>
</tr>
</tbody>
</table>
8.2 RECOMMENDATIONS

The next major phase of the Two-Tier research is the implementation of the Tier II strategy on pilot projects. Companies will implement the details of the strategy differently. These pilot implementation efforts will provide valuable opportunities to evaluate different approaches, including the process itself, cost, benefits, and methods of measurement. Over time, it may be possible to evaluate implementation efforts across projects – for instance, five different management training models – and summarize what appeared to work well, what appeared to need improvement, and identify common elements that can begin to form the foundation of a “best practice” for implementation.

Owners and contractors should investigate the potential long term benefits of a cooperative regional approach to workforce development.

Some changes to the questionnaires and the metrics may be justified, based on questions raised during the baseline data collection and the subsequent data analysis. Items recommended for consideration include:

- Define a “certified” journey-level craft worker to be NCCER “Certified Plus” or to possess a union journey-level card,
- Define “continuous education and training” to include all training officially recognized and documented by the contractor, including safety training, technical training, and management/supervisory training,
- Develop a “master list” of Tier II skills and/or crafts to standardize the definitions and evaluation of multiskilling and multicrafting,
- Modify the questionnaire to more accurately study the issue of core vs. transient craft workers, and
- Clarify the development, refinement, and “certification” of individual management (administrative, computer, planning, and job management)
skills. Given the different procedures and systems used to conduct short-interval planning, for example, it is unlikely that an industry-wide certification is feasible in the near future, although that is a valuable long-term goal. One logical solution for the immediate future is for companies to develop their own certifications, based on their specific procedures and project systems. It may be more effective to collect data regarding individuals’ actual use of these skills on the job (e.g., frequency of use, diversity versus specialization in various administrative and computer skills) rather than simply their training and certification status.

8.3 CONTRIBUTIONS

This dissertation extends the CCIS workforce research effort through the following contributions:

- It documents the first comprehensive attempt to provide quantitative guidance regarding the implementation of the Tier II Construction Workforce Strategy. It provides an initial assessment of the activities required to achieve an advanced level of Tier II implementation, and develops estimated costs and benefits for an example project.

- It provides a methodology (Figure 3.5) that industry organizations can use to develop informed decisions regarding the benefits and costs of implementing the Tier II strategy, or any structured workforce development and management strategy.

- It quantifies the current state of the industry per the Tier II metrics, which provides a benchmark for future comparison.

- It presents a new paradigm in which to implement Tier II that mitigates the common reluctance in the industry to invest in a transient workforce.
Appendix A: Industry Participants

Dan Bennet, Tradesmen International, Inc.
Bill Bobo, Houston Business Roundtable
Rilene Burgess, S&B Engineers and Constructors, Ltd.
Keith Byrom, Zachry Construction Corporation
Thomas Collins, S&B Engineers and Constructors, Ltd.
Randy Evans, BE&K, Inc.
Butch Ford, Austin Industrial
Dave Fuqua, Zachry Construction Corporation
Paris Gill, S&B Engineers and Constructors, Ltd.
Ned Givens, Construction Industry Institute
David Goins, Tennessee Valley Authority
Robert Heath, Rohm and Haas Company
Dickie Jones, Fluor
Myron Laurent, BE&K, Inc.
Mike Stilley, S&B Engineers and Constructors, Ltd.
Jim Stinson, Houston Gulf Coast Building and Construction Trades Council
Don Whyte, National Center for Construction Education and Research
Lowell Wiles, Williams Group International, Inc.
Appendix B: Tier II Individual Metrics
### Individual Technical Skills

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Craft Certification</td>
<td>4.0</td>
<td>Certified in 3 crafts</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 2 crafts</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certification</td>
<td>0</td>
</tr>
<tr>
<td>Technical Experience</td>
<td>4.0</td>
<td>More than 10 years of experience at the certified craft level</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 years of experience at the certified craft level</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 1 year of experience at the certified craft level</td>
<td>0</td>
</tr>
<tr>
<td>Continuous Training and Education</td>
<td>2.0</td>
<td>More than 200 hours of training and skill updating in the last 3 years</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100 hours of training and skill updating in the last 3 years</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training or skill updating since first craft certification</td>
<td>0</td>
</tr>
</tbody>
</table>

Total =

---

156
### Individual Management Skills

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative (cost management, scheduling, material management, RFI, and estimating)</td>
<td>1.0</td>
<td>Certified in at least 4 administrative skills</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 2 administrative skills</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certified administrative skills</td>
<td>0</td>
</tr>
<tr>
<td>Computer (email/ internet, word processing, spreadsheet, scheduling, estimating, CAD, and material management)</td>
<td>1.0</td>
<td>Certified in at least 5 computer skills</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Certified in 3 computer skills</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No certified computer skills</td>
<td>0</td>
</tr>
<tr>
<td>Planning (material, equipment, tools and information request, short-term planning, and scheduling)</td>
<td>3.0</td>
<td>Certified in planning skills</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160 hours of training but not certified in planning skills</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training and certification</td>
<td>0</td>
</tr>
<tr>
<td>Job Management (crew coordination, inter- and intra-craft coordination, selection of work means and methods, and leadership)</td>
<td>2.0</td>
<td>Certified in job management functions</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160 hours of training but not certified in job management functions</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No training and certification</td>
<td>0</td>
</tr>
<tr>
<td>Work Record (safety, attendance/ truancy, quality, productivity, and initiative)</td>
<td>3.0</td>
<td>Superior in all categories</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Superior in some, modest in others</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weak in most categories</td>
<td>0</td>
</tr>
</tbody>
</table>

Total =

### Individual Score Summary

<table>
<thead>
<tr>
<th></th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Technical Skills Score =</td>
<td>100</td>
</tr>
<tr>
<td>Individual Management Skills Score =</td>
<td>100</td>
</tr>
</tbody>
</table>

### Individual Tier II Score = 200

A minimum combined score of 150 points is necessary to qualify as a “Tier II craft worker.”

157
Appendix C: Tier II Project Metrics
### Project Craft Technical Skills

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Score</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score from Individual Evaluation on Technical Skills *</td>
<td>7.0</td>
<td>Greater than 75 points</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 points</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 25 points</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Tier II Workers</td>
<td>3.0</td>
<td>40% or more of journeymen are certified as Tier II workers</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20% of journeymen are certified as Tier II workers</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 10% of journeymen are certified as Tier II workers</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* for project's key crafts

### Project Craft Management Skills

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Score</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Score from Individual Evaluation on Management Skills *</td>
<td>10.0</td>
<td>Greater than 75 points</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 points</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 25 points</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* for project's key crafts

### Information Technology Utilization

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Score</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated</td>
<td>6.0</td>
<td>All information* is stored, integrated, continuously updated, and accessed by Tier II workers electronically</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td></td>
<td>3 types of information* are stored, integrated, continuously updated, and accessed by Tier II workers electronically</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td></td>
<td>Information* is not directly accessed by Tier II workers</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware</td>
<td>4.0</td>
<td>Tier II workers have wireless, wearable computers</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hardware is nearby and shared among crews</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No hardware is available to Tier II workers</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Information includes schedule, costs, materials and equipment management, safety, drawings, and worker skills.

Total =
### Craft Utilization

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Score</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crew Mix</td>
<td>4.0</td>
<td>Key crafts' crews (on avg.) have at least 40% of Tier II workers</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Key crafts' crews (on avg.) have at least 20% of Tier II workers</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 50% of key crafts' crews have Tier II workers</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of Multiskilled Workers</td>
<td>2.0</td>
<td>Key crafts' crews (on avg.) have at least 40% multiskilled workers</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Key crafts' crews (on avg.) have at least 20% multiskilled workers</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 50% of key crafts' crews have multiskilled workers</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Worker Turnover (Total Hires/Peak Workforce)</td>
<td>4.0</td>
<td>Less than 2</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equal to 3</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Greater than 4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Organization

<table>
<thead>
<tr>
<th>Elements</th>
<th>Weights</th>
<th>Evaluation Criteria</th>
<th>Score</th>
<th>Score</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communications</td>
<td>6.0</td>
<td>Proactive information flow to and from workers about the project, established formal &amp; informal channels, open access to management, frequent meetings with workers, all workers are familiar with all aspects of the project</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Informal communication channels, regular meetings with workers, workers can receive project information requested, open door policy</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid hierarchical structure for communication, only information that management deems necessary to workers is provided.</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Performance Work Place</td>
<td>4.0</td>
<td>Delegation of appropriate authority and accountability to High Performance Work Teams (HPWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in HPWT approach. Expected utilization by crews of management</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hierarchical structure, but with 2-way information &amp; idea flow between crews and management</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rigid hierarchical structure</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total = ______
### Project Score Summary

<table>
<thead>
<tr>
<th>Index</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Craft Technical Skills Index</td>
<td>100</td>
</tr>
<tr>
<td>Project Craft Management Skills Index</td>
<td>100</td>
</tr>
<tr>
<td>Information Technology Utilization Index</td>
<td>100</td>
</tr>
<tr>
<td>Craft Utilization Index</td>
<td>100</td>
</tr>
<tr>
<td>Organization Index</td>
<td>100</td>
</tr>
<tr>
<td><strong>Tier II Index</strong> = SUM/50</td>
<td>10.0</td>
</tr>
</tbody>
</table>
Appendix D: Workforce Assessment Package Questionnaires
WORK FORCE ASSESSMENT TOOL
INDIVIDUAL SKILL ASSESSMENT

1. In how many crafts are you certified? __________
   Please list those crafts and who provided the certification:

   In the next 12 months, how many additional crafts will you be certified in? ______
   Please list those crafts:

2. How many years of experience, in your primary craft, do you have at the certified craft level? ________ yrs

3. How many hours of craft training and craft skill updating have you had in the last 3 years? (including recertification and safety) ____________ Hrs

4. Please check each of the following administrative skills in which you are proficient*:
   - □ Cost Management
   - □ Request for Information
   - □ Material Management
   - □ Scheduling
   - □ Estimating

5. Please check each of the following computer skills in which you are proficient*:
   - □ E-mail/internet
   - □ Scheduling
   - □ Material Management
   - □ Word processing
   - □ Estimating
   - □ Spreadsheet
   - □ Computer Aided Design (CAD)

6. How many total hours of training do you have in planning skills? (Material, equipment, tools and information request, short-term planning, and scheduling) (Include FORMAL classroom training) ____________ Hrs
   Are you certified in planning? □ yes □ no
   Are you proficient* in planning skills? □ yes □ no

7. How many combined hours of training do you have in job management skills? (Crew coordination, inter-and intra- craft coordination, selection of work packages, and leadership) (Include FORMAL classroom training) ____________ Hrs
   Are you certified in job management? □ yes □ no
   Are you proficient* in job management skills? □ yes □ no

8. Have you worked for this company before this project? □ yes □ no

*Proficient- a skill in which you are competent and capable with little or no supervision
9. For the last year, please rate the your personal performance record (including safety, attendance, quality, productivity, and initiative) on a scale from 0 to 10 with 0 being weak, 5 being modest and 10 being superior.

<table>
<thead>
<tr>
<th>Performance</th>
<th>Weak</th>
<th>Modest</th>
<th>Superior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Record</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

10. Do you have any experience in training unskilled workers in tasks as an instructor or a mentor?  □ yes □ no

   If yes, have you ever been certified as an instructor?
      □ yes □ no

11. How many people are on your crew (not including the supervisor/foreman)? _______

   How many craftsmen/journeymen are on your crew? _______

   How many apprentice/helpers are on your crew? _______
WORK FORCE ASSESSMENT TOOL
INDIVIDUAL BACKGROUND QUESTIONNAIRE

1. What is your age? ______________

2. What is your gender?    ☐ Female       ☐ Male

3. What is your country of origin? ☐ USA    ☐ Other (please specify) ______________

4. What is your native language? ☐ English   ☐ Spanish    ☐ Other (please specify)________

4. What is your highest level of education achieved?
☐ 0-8 years of school
☐ Some high school
☐ High school diploma
☐ GED equivalent
☐ Completed vocational or technical program
☐ Some college (No degree)
☐ Associate degree (2 year program)
☐ Bachelors degree (4 year program)
☐ Some post graduate education (Masters, Ph.D.)
☐ Masters degree
☐ Ph.D.
☐ Other (please specify)______________

5. What is your present job title? (Check one)
☐ Project Manager
☐ Assistant Project Manager
☐ Superintendent
☐ Assistant Superintendent
☐ Craft Superintendent
☐ General Foreman
☐ Foreman/ Supervisor
☐ Craftsman / Journeyman
☐ Apprentice/Helper
☐ Other (please specify)____________

6. In what crafts do you work at the journeyman level? (Check all that apply)
☐ Boilermaker
☐ Carpenter
☐ Concrete Finisher
☐ Crane Operator
☐ Equipment Operator
☐ Electrician
☐ Instrument Fitter
☐ Glass/Glazing Worker
☐ Instrument Technician
☐ Insulation Worker
☐ Laborer
☐ Mason
☐ Welder (What type of welder? ______________)
☐ Millwright
☐ Operating Engineer
☐ Plumber
☐ Painter
☐ Pipe fitter
☐ Roofer
☐ Reinforcing Rodman
☐ Rigger
☐ Structural Ironworker
☐ Sheetmetal Worker
☐ Other (list) _______________________

If you checked more than one, please indicate which is your primary craft: ______________
7. How did you receive your craft training? (Check all that apply)
- Passed NCCER Wheels of Learning Program in your craft
- Graduate of union sector apprenticeship program
- Graduate of company non-union apprenticeship program
- Basic military training in construction
- Graduate of company craft certification program
- Military “C” school training in a craft
- On the job training only
- Vocational program
- Other (specify) ________________

8. In your current job, do you have supervisory responsibility?  □ Yes  □ No

9. What is your current pay rate, not including overtime? $ _______ per hour
   If you are not paid by the hour but you are salaried, what is your salary $ _______ per year

10. How many total weeks did you work in construction in 2001? ________ Weeks
    (52 weeks = 1 year)

   On average, how many hours per week did you work in construction in 2001? _____

11. How long have you been with your present firm? ________Years ________Months

12. For how many different construction companies have you worked? ________

13. On what type of construction projects have you normally worked?
   □ Union  □ Open Shop  □ Both

14. How many years of experience in construction do you have in each of the following categories?

<table>
<thead>
<tr>
<th>Years</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>_____</td>
<td>Apprentice / Helper</td>
</tr>
<tr>
<td>_____</td>
<td>Journeyman/ Craftsman</td>
</tr>
<tr>
<td>_____</td>
<td>Foreman</td>
</tr>
<tr>
<td>_____</td>
<td>General Foreman</td>
</tr>
<tr>
<td>_____</td>
<td>Assistant Superintendent</td>
</tr>
<tr>
<td>_____</td>
<td>Superintendent</td>
</tr>
<tr>
<td>_____</td>
<td>Assistant Project Manager</td>
</tr>
<tr>
<td>_____</td>
<td>Project Manager</td>
</tr>
</tbody>
</table>

   Your Total years of experience in construction ____________

15. Do you know how to use a computer?  □ Yes  □ No (if “No” jump to question 18)

16. How long have you been using a computer? ________ years
17. Where did you acquire your computer skills?
☐ Self-taught off the job
☐ By on-the-job use
☐ Through company sponsored training
☐ Formal education / schooling
☐ Other (please specify)______________________________

18. Do you have any job planning, management or administrative skills? (See box below for skills)
☐ Yes  ☐ No (if “No” jump to question 20)

Example of skills: Cost and materials management, Scheduling, Estimating, RFI, crew coordination, selection of work packages, leadership

19. Where did you acquire those planning, management and administrative skills?
☐ Self-taught off the job
☐ By on-the-job use
☐ Through company sponsored training
☐ Formal education / schooling
☐ Other (please specify)______________________________

20. Are you satisfied with your pay?  ☐ Yes  ☐ No

For the following questions, please indicate your response on a scale from 1 to 5.

21. How satisfied do you feel with your career in the construction industry?

1       2     3     4      5
Very                Neutral     Very
Dissatisfied                      Satisfied

Why? ______________________________________________________________

22. Planning and progress information should be shared between crews.

1       2     3     4      5
Not Desirable                       Neutral                  Desirable
23. How do you feel about entering and obtaining project information in a portable, wireless computer at the work face? This information would include schedule, costs, material and equipment, management, safety, drawings and skills.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Desirable</td>
<td>Neutral</td>
<td>Desirable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

24. How do you feel about carrying around a portable, wireless computer (from previous question) at the work face?

<table>
<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Desirable</td>
<td>Neutral</td>
<td>Desirable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

25. All crews on the project should include multicrafted workers?

<table>
<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Desirable</td>
<td>Neutral</td>
<td>Desirable</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please give your perception of the following work practices at a construction site. Rate on a scale from 1 to 5. (Circle only one).

26. The job of the crew should be defined so that crew members see it as a team project. All crew members (not only the foreman) ensure that it is planned and executed properly.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

27. There should be a rigid chain of command in which crew members do not participate in coordinating the job of the crew, only the foreman should do it.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

28. Tasks should be assigned to the crew as a team, so that the crew as a whole has a responsibility for which the crew as a whole is held accountable.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
29. Tasks should be assigned for each crew member so that the individual has a specific responsibility for which only he/she is held accountable.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

30. It would be easier to get the job done if all experienced journeymen were also able to perform tasks that are typically considered “management” functions (cost management, scheduling, estimating, materials management, Request for Information (RFI)).

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

31. Craftsmen should adapt to the use of new technology that improves productivity or work conditions.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

32. You would be willing to go through training in the following administrative skills: cost management, scheduling, material management, Request for Information (RFI), and estimating.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

33. You would be willing to go through training in the following computer skills: e-mail/internet, word processing, spreadsheets, scheduling, estimating, computer aided design (CAD) and materials management.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>

34. You would be willing to go through training in the following planning skills: materials, equipment, tools and information request, short-term planning, and scheduling.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Disagree</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Strongly Agree</td>
<td>Strongly Agree</td>
</tr>
</tbody>
</table>
35. You would be willing to go through training in the following job management skills: crew coordination, craft coordination, selection of work means and methods, and leadership.

1       2     3     4      5
Strongly Disagree          Neutral            Strongly Agree

Thank you.

Your help is greatly appreciated!
WORK FORCE ASSESSMENT TOOL
PROJECT MANAGEMENT PRACTICES QUESTIONNAIRE

1. What is the average ratio of Crewmembers to Foremen/Supervisors on this project (for the key crafts only)? ____ to 1

2. To date for this project:
   What is the number of Total Hires? ___________
   What is the Peak Work force? ___________
   What is the number of fires? ___________
   What is the number of quits? ___________

3. Please indicate your project’s communication structure on the scale from H to P with H representing a hierarchical structure and P representing a proactive two-way information flow structure for each element on your project:

Communication- Project Management with Foremen
   H = Rigid hierarchical structure for communication, only information that management deems necessary to foremen is provided
   I = Informal communication channels, regular meetings with foremen, foremen can receive project information requested, open door policy
   P = Proactive information flow to and from foremen about the project, established formal & informal channels, open access to management, frequent meetings with foremen, all foremen are familiar with all aspects of the project

   H |_________| I |_________| P

Communication- Project Management with Craftsmen
   H = Rigid hierarchical structure for communication, only information that management deems necessary to craftsmen is provided
   I = Informal communication channels, regular meetings with craftsmen, craftsmen can receive project information requested, open door policy
   P = Proactive information flow to and from craftsmen about the project, established formal & informal channels, open access to management, frequent meetings with craftsmen, all craftsmen are familiar with all aspects of the project

   H |_________| I |_________| P

Communication- Foremen with Craftsmen
   H = No organized regular meetings with craftsmen and feedback is discouraged
   I = Regular organized project meetings with craftsmen and regular queries to craftsmen about concerns or suggestions
   P = Frequent, formal project meetings with craftsmen, regular queries to craftsmen and two-way information flow between craftsmen and upper management

   H |_________| I |_________| P
High-Performance Work Teams

\(H\) = Rigid hierarchical structure

\(I\) = Hierarchical structure, but with 2-way information & idea flow between crews and management

\(P\) = Delegation of appropriate authority and accountability to Self-Directed Work Teams (SDWT). Clear definition of authority, accountability and expectations to each team. Training of all teams in SDWT approach. Expected utilization of management skills by crews and IT information available through craftsmen. Task assigned to crews as teams. Some experienced journeymen perform tasks that typically considered “management” tasks. Crews adapt to new technology. Positive reward systems in place.

<table>
<thead>
<tr>
<th>H</th>
<th>I</th>
<th>P</th>
</tr>
</thead>
</table>

4. Does management use a formal, short interval planning process? □ yes □ no
   If yes, what is the frequency and look-ahead window for this planning process?

Do you have a formal CPM schedule? □ yes □ no
   If yes, how often is it updated? (for example, weekly, monthly, etc.)

5. In the matrix below, fill with an “X” all combinations which apply to the project on which you are currently working.

<table>
<thead>
<tr>
<th>Information Type</th>
<th>Schedule</th>
<th>Cost</th>
<th>Materials &amp; Equip. Mgmt.</th>
<th>Safety</th>
<th>Drawings</th>
<th>Worker Skills</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information is electronically updated by Craftsmen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information is electronically updated by Field Supervisors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information is directly accessible to Craftsmen (electronically)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information is directly accessible to Field Supervisors (electronically)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. How electronically integrated is your project information? (Please place a check in the appropriate box)

<table>
<thead>
<tr>
<th>No Integration</th>
<th>Some Integration</th>
<th>Integration of all information</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>S</td>
<td>A</td>
</tr>
</tbody>
</table>

172
7. Please place a check mark in all the boxes that apply:

Wireless handheld computers are used on the site
☐ by Craftsmen ☐ by Field Supervisors

Computers are near the work face and are shared among crews? ☐ yes ☐ no

Computers are available on the site
☐ for Craftsmen ☐ for Field Supervisors

8. What other IT applications are used on your site? (For example: bar code scanning, radio frequency applications, GPS, digital cameras, wireless networks, etc.)
Glossary

ABC  Associated Builders and Contractors
AFL-CIO  American Federation of Labor – Congress of Industrial Organizations
AGC  Associated General Contractors of America
BAT  Bureau of Apprenticeship and Training, U.S. Department of Labor
B/C  Benefit-cost ratio
BCTD  Building and Construction Trades Department of the AFL-CIO
BEA  Bureau of Economic Analysis, U.S. Department of Commerce
BRT  The Business Roundtable
CCIS  Center for Construction Industry Studies
CEH  Compass Educational Holdings
CICE  Construction Industry Cost Effectiveness Project
CIF  Construction Innovation Forum
CII  Construction Industry Institute
CINESTA  Construction Industry Network for Essential Skills Training in Alberta
CLRA  Construction Labour Relations
COAA  Construction Owners Association of Alberta
CPWR  The Center to Protect Workers’ Rights, BCTD, AFL-CIO
CSHR  Ray Marshall Center for the Study of Human Resources
CURT  The Construction Users Roundtable
ESL  English as a Second Language
FDS  Foreman Delay Survey
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FM</td>
<td>Foreman</td>
</tr>
<tr>
<td>FMI</td>
<td>Fails Management Institute</td>
</tr>
<tr>
<td>H2H</td>
<td>Helmets to Hardhats</td>
</tr>
<tr>
<td>IBB</td>
<td>International Brotherhood of Boilermakers</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>JCW</td>
<td>Journey-level craft worker</td>
</tr>
<tr>
<td>LCI</td>
<td>Lean Construction Institute</td>
</tr>
<tr>
<td>LUF</td>
<td>Labor Utilization Factor</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet</td>
</tr>
<tr>
<td>NCACP</td>
<td>NCCER National Craft Assessment and Certification Program</td>
</tr>
<tr>
<td>NCCER</td>
<td>National Center for Construction Education and Research</td>
</tr>
<tr>
<td>NTSA</td>
<td>NCCER National Training Service Agreement</td>
</tr>
<tr>
<td>OATELS</td>
<td>Office of Apprenticeship Training, Employer and Labor Services, U.S. Department of Labor</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
</tr>
<tr>
<td>PPC</td>
<td>Percent Planned Complete</td>
</tr>
<tr>
<td>QC</td>
<td>Quality Control</td>
</tr>
<tr>
<td>RFI</td>
<td>Request for Information</td>
</tr>
<tr>
<td>ROI</td>
<td>Return on Investment</td>
</tr>
<tr>
<td>Tier II JCW</td>
<td>Tier II journey-level craft worker</td>
</tr>
<tr>
<td>TVA</td>
<td>Tennessee Valley Authority</td>
</tr>
<tr>
<td>UBC</td>
<td>United Brotherhood of Carpenters and Joiners of America</td>
</tr>
<tr>
<td>WHs</td>
<td>Work hours</td>
</tr>
<tr>
<td>WS</td>
<td>Work Sampling</td>
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Bibliography


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Vita

Michael Philip Pappas was born February 19, 1967 in Carbondale, Illinois to James and Phillis Pappas. He graduated from the University of Missouri-Rolla in December 1989 with a Bachelor of Science in Civil Engineering.

Michael earned a regular commission in the United States Navy Civil Engineer Corps in June 1990 as a Distinguished Naval Graduate from Officer Candidate School. He served eight years of active duty, managing facilities and construction projects for the Navy and Marine Corps in the United States and overseas.

In August 1998 he entered The University of Texas at Austin Construction Engineering and Project Management program and completed a Masters of Science in Engineering in May 2000. He then managed land development projects for the Farnsworth Group, Inc., an Engineering News Record Top 300 design firm in Bloomington, Illinois.

In January 2002 he began doctoral studies in Civil Engineering at The University of Texas at Austin, and simultaneously completed the Graduate Portfolio Program in Dispute Resolution. He has published refereed conference papers on construction management, workforce development, and dispute resolution, and has co-authored a technical report for the Federal Facilities Council. His research assistantship with the Center for Construction Industry Studies culminated in this dissertation.

Michael is a registered Professional Engineer in Missouri. He is married to Barbara Clark Pappas, formerly of St. Louis, Missouri. They have two sons, James and John.

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This dissertation was typed by the author.