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PLANNING AND SCHEDULING A MULTISKILLED WORKFORCE

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MULTISKILLED WORKFORCE**

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EXECUTIVE SUMMARY

This document presents a progress report for the Planning and Scheduling of a Multiskilled Workforce Study research team of the Center for Construction Industry Studies. The primary purpose of this research is to document current practices that construction companies follow and to suggest a methodology for planning and scheduling a multiskilled workforce.

During this program of study, the research team accomplished six tasks. First, The University of Texas at Austin study team was assembled. Second, we developed a list of objectives for this research effort. Third, we conducted a thorough review of literature in the fields of engineering, operations management, and decision sciences. Fourth, we conducted a total of 51 personal interviews, and 15 telephone interviews from 12 different companies. The interviews were conducted at the planner and manager level, superintendent and foreman level, and craft worker level. Fifth, the study developed a methodology for planning and scheduling a multiskilled workforce. Finally, the study team identified specific questions regarding tools and methods for scheduling that need to be considered for further research.

This report outlines the findings from these initial tasks and research questions for future work. This study facilitated an in-depth understanding of the management methods utilized on a multiskilled project. These findings provide a sound basis for future work, and suggest the development of future research to assist in the crew composition and project staffing process to ensure gaining the maximum benefits from multiskilling.

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CHAPTER 1: INTRODUCTION

Sixty percent of construction companies surveyed by the Business Roundtable in 1997 reported difficulties recruiting and maintaining their workforce (TBR 1997). The main causes of these shortages are the limited number of workers entering the industry and the limited supply of qualified candidates (Craftworkers Crisis 1998). The poor image of the industry makes it difficult to attract new workers and the lack of opportunities for training and career growth leads to high turnover rates (TBR 1997; Liska 1998).

New labor strategies have been suggested to address these concerns and produce a more efficient use of craft workers. Multiskilling is one of these strategies where workers possess a range of skills which allows them to participate in more than one work process. The workers may have one specific skill in which they are specialized, but their role in a construction project is not limited to only that skill. Traditional rigid craft boundaries are blurred or eliminated, and the worker is allowed and expected to work in various crafts as long as the task is performed proficiently and safely (Stanley 1997). Previous research efforts demonstrated benefits of multiskilling including potentially a 5-20% labor cost savings, a 35% reduction in required workforce, a 47% increase in average employment duration, and an increase in earning potential for multiskilled workers (Burleson 1998).

Experiences with multiskilling in other industries have produced similar results. Brusco and Johns (1995) developed an analysis of cross-training policies using data collected from maintenance operations in a paper mill through the use of linear programming. They focused on the importance of cross-training as a source of scheduling flexibility. Their results suggested that an adequate composition of a multiskilled force could reduce staffing costs. Gerard Campbell (1998) developed a model for allocating cross-trained workers in a multi-department service environment. Results showed that the benefits of cross-utilization can be substantial, and in many cases a small degree of cross-training can capture most of the benefits.

The objectives of the research are summarized below:

1. To understand and document the current methods that the construction industry is applying to plan and schedule a multiskilled workforce.
2. To develop a methodology to assist the construction industry to achieve efficient planning and scheduling of a multiskilled workforce to assure that project performance will be benefited by the use of multiskilling.

The research consisted of the following activities:

- The study team and an industry advisory panel were assembled;
- Initial objectives were established;
- A thorough literature review was completed;
- Fifty-one direct interviews with 7 companies were conducted;
- Fifteen phone interviews with 7 companies were conducted; and
- A methodology for planning and scheduling of a multiskilled workforce was developed.

The remainder of this report is based on the results of these activities. Chapter 2 summarizes the site visits and interviews, and also portrays the current knowledge regarding multiskilling. Chapter 3 suggests the planning and scheduling methodology developed from observations of current practices. Chapter 4 summarizes the needs for tools that are required for a more effective crew composition process. The fifth and final chapter summarizes our findings and future plans.

CHAPTER 2: KNOWLEDGE ACQUISITION

2.1 Site Visits and Interviews

Companies that have implemented multiskilling were studied in the industrial, petrochemical, infrastructure, and maintenance areas of the construction industry. The industry areas studied were selected according to the availability of information. One maintenance unit for aircraft at an Air Force Base was also surveyed to compare the current practices of the maintenance and construction industries, and analyze their similarities and differences.

Visits to these companies facilitated an in-depth understanding of the management methods utilized on a multiskilled project. Table 2.1 presents the main characteristics of the companies that were visited. Each of the visited companies develops projects in different areas of the industry, and their projects are located throughout the US and the world.

Table 2.1 Characteristics of Visited Companies

Company	Projects' location	Industry Area
Cianbro Corporation	New England and Mid-Atlantic East Areas	heavy construction, heavy industrial
The H.B. Zachry Company	Gulf of Mexico, Southwest and Mid-Atlantic East Area.	heavy industrial, petrochemical, infrastructure and some small capital projects.
The Mundy Company	Gulf of Mexico and the East Coast Area	maintenance and commercial projects.
Brown and Root Engineering Construction	US, 60 countries	heavy industrial, transportation, commercial, industrial and institutional constructions
US Air Force maintenance unit	Oklahoma	aircraft maintenance

Additional information was gathered through several telephone interviews with managers from other companies that had implemented multiskilling. Table 2.2 presents the amount of interviews conducted during this research effort according to job title and

company. Due to the nature of the study, most of the interviews were held with managers, planners, and superintendents. Craft workers were also interviewed to verify the information provided by managers.

Table 2.2 Personnel Interviewed

Job Title	Number of Personal Interviews	Number of Telephone Interviews
Managers and Planners	Cianbro Corporation: 18 The H.B. Zachry Company: 2 Brown and Root: 3 The Mundy Companies: 3 Tinker AFB Maintenance Unit: 2	Cianbro Corporation: 4 Beacon Construction: 2 Watkins/Inland Construction: 2 BE&K: 3 Masonry Arts, Inc: 1 Shieg and Assoc: 1
Superintendents and Foremen	Cianbro Corporation: 4 Brown and Root: 1 Tinker AFB Maintenance Unit: 1 Austin Commercial Inc.: 2	Watkins/Inland Construction: 2
Craft Workers	Ciabro Corporation: 5 Spaw Glass Inc.: 10	
Total	51	15

2.2 Definition of Multiskilling

The surveyed companies define multiskilling as the ability of workers to perform different crafts. Eighty percent of the companies studied differentiate a multiskilled worker from a multicraft worker. The latter is proficient, not just knowledgeable in more than one craft. The number of crafts in which workers are proficient are determined by the number of skill assessment tests they pass.

In a multiskilled workforce, crafts are grouped according to the common skills among them. The most common divisions of crafts are civil, mechanical, electrical work and equipment operators. A civil worker is trained or develops skills in a few crafts that are part of the civil divisions but usually not in other divisions. The worker may participate in tasks outside of his or her area at a helper level.

2.3 Reasons for Implementing Multiskilling

Although each of the surveyed companies has different characteristics and approaches multiskilling in different manners, they have the same main reasons for implementing multiskilling. Contractors believe multiskilling makes them more competitive because as workers stay longer on a project, the number of fired and newly hired employees decreases thus reducing labor costs. The surveyed companies consider a multiskilled workforce to be more productive because idle and transition time is reduced. There is no need to change crews like there is in a single-skilled workforce. They also believe that the more skilled a worker is, the more productive he or she works, because he or she can integrally visualize the constructive process (Dolce 1998). Although managers accept that they have not measured the exact increase in productivity, an average increase of twenty percent was acknowledged by all of the surveyed companies. The companies have not measured exact increases in productivity mainly because the varied composition of the workforce from project to project makes an exact value difficult to obtain.

Implementing multiskilling may also reduce labor shortages because fewer workers are required to perform the same number of tasks. It also keeps good workers at the company. Multiskilled workers may be assigned to a broad variety of tasks even though these do not involve their main craft. Thus, the likelihood of being laid off is lowered. However, multiskilling does not completely overcome the effects of labor shortages. Companies need to develop additional policies to retain their workers.

Part of the success of the surveyed companies results from the treatment of their people, and their utilization of multiskilling as a strategy to improve employees' conditions. Some of the workers' concerns may be addressed with multiskilling. For example, multiskilling makes workers more valuable and gives them more possibilities to advance and develop a career path. Multiskilling ensures job continuity because workers can be assigned to many types of work assignments. Some workers want to stay in the same region. If they are multiskilled, they can participate in many types of projects without being relocated to different areas because they are able to perform many different tasks and are willing to learn more skills if required. Also, the implementation of multiskilling gives workers the opportunity to develop skills that will allow them to maintain a good job even if they develop physical limitations (Burton 1998).

Multiskilling also increases motivation by increasing the productivity of workers, decreasing idle time and encouraging participation.

2.4 Types of Multiskilled Projects

The surveyed companies consider that multiskilling is the appropriate labor strategy for a maintenance project where it is not always possible to forecast the activities that will be performed. Having a multiskilled workforce ensures it will be able to perform any activity because multiskilling workers have a broad variety of skills. Moreover, workers will be able to diagnose operational problems that involve many trades. The use of multiskilling provides a crew with the capability to respond to any type of situation on the site (Kohlman 1998).

Capital projects can also be appropriate for multiskilling. A representative of Cianbro Corporation explained how the company utilizes multiskilling as a means to participate in a broad variety of projects, giving them increased flexibility (Burton 1998). They employ most of the same workers in a variety of heavy construction and industrial projects. Multiskilling is also considered proper for developing small capital projects that involve activities with relatively short duration (Cooley 1996; Wallace 1996). Small projects are usually within a specialized industry area and involve limited types of tasks that may be accomplished with the skills included in the workforce. The workers are also specialized in certain area, according to the type of capital projects in which they participate. The surveyed companies argue that other types of projects involving long-term activities increase costs when employing multiskilled workers on them because they are paid more, and their talents are not used to perform a variety of tasks. Thus, labor cost increases because single-skilled worker can execute the same tasks for lesser pay.

2.5 Limitations to the Implementation of Multiskilling

The surveyed companies consider multiskilling a valuable labor strategy with many benefits. However, they encounter obstacles while implementing multiskilling in their workforces for four reasons: the high mobility of workers, safety issues related to some skills, lack of support for training, and unions' reactions to this labor strategy. The high mobility of workers limits the number of skills they may develop while being part of

the company and also reduces the effectiveness of a company's training efforts. In addition, training is another limitation of multiskilling because most owners approve the utilization of a multiskilled workforce because it reduces costs, but they do not support training unless it is highly required. Furthermore, some skills involve safety issues that limit the possibility of assigning a less-skilled worker to participate in these tasks. Some tasks should be reserved to particular trades, especially when there is a large portion of work being performed. Welding, electrical work and hanging steel are some examples of this safety limitation (Massey and Jarvis 1996; Nixon 1998).

Unions' jurisdictions and rules may hinder the implementation of multiskilling in certain areas. Unionized workers perform tasks only within their craft jurisdiction; one specialized crew has the exclusive right to a particular craft and other crews are not allowed to perform the task even if they have the required skills. This policy assures workers have adequate training and experience in each area. As multiskilling avoids craft jurisdiction by assigning tasks to workers according to their abilities and the project's needs, not according to their affiliation, unions may resist the implementation of this labor strategy. Nevertheless, agreements with labor unions may be established to broaden the working area of their members.

2.6 Multiskilling on Large Projects vs. Other Projects

The surveyed companies' approach to multiskilling could be categorized as one of two types depending on their workforce size. When a construction project is developed with a large workforce size totaling more than 200 workers, it commonly includes both, a multiskilled and a single-skilled workforce. Maintaining a large workforce composed solely of multiskilled workers is difficult because to become highly skilled, a worker must stay in the industry for a long period of time. This is not a common pattern at the present time (Dolce 1998). Under these circumstances, a project has a basic workforce of multiskilled workers from beginning to end, and additional transient specialized workers.

During the initial and final stages of construction projects, there are a broad variety of tasks to perform that involve different skills. Performing these tasks with single-skilled workers generates a high number of hires and fires. Implementing a multiskilled workforce reduces this costly inconvenience. These workers are kept during

the entire project, performing a great variety of tasks and crafts, mostly within one area of specialization. They also help in other areas with the security of having continued employment.

During the peak time of the construction phase almost all workers are assigned to perform tasks in the craft in which they are specialized, and many single-skilled workers are hired due to the high labor demand generated by the large number of required tasks. This increased hiring makes certain that the project progresses quickly and profitably. During this peak period, there are many specialized tasks to keep workers busy practicing their main crafts. Managers always try to maximize the advantages of using multiskilled workers; these workers may practice tasks they are specialized in or work as helpers on other crews if they do not have any assignment and other crew needs help.

When a company develops projects with a workforce of fewer than 200 workers, it tries to keep the same workers on the project for as long as possible. The workforce should include workers capable of performing the skills necessary for the project. This approach is commonly utilized in maintenance or small capital projects, within a specialized industry.

CHAPTER 3: PLANNING AND SCHEDULING METHODOLOGY

DEVELOPED FROM OBSERVATIONS

This methodology is based on the documentation of current practices at surveyed companies. It may be followed by any company that wants to implement a multiskilled workforce in a project, and explains how the concepts of multiskilling should be approached during each phase of a construction project. Figure 3.1 presents a summary of the methodology.

3.1 Phase I: Implementation of Multiskilling in the Company

Phase I includes the required changes in the company's systems and culture in order to support multiskilling. The four main elements that should be determined during this phase are recruiting, training and compensation policies, and skills' association procedures. These elements are important to give companies a competitive advantage through the use of multiskilling (Villalobos 1997).

The recruiting strategy determines how to identify the skills in which workers are proficient. According to the procedures followed by the companies surveyed, the recruiting strategy should include a skill assessment procedure to evaluate the employees' proficiency in a given trade. This information should be kept in a database that is designed according to the company's specific needs.

Training strategies vary from company to company. According to interviews, most training in a multiskilled workforce is informal, but it may also involve off-site classroom educational programs. By participating in many types of tasks, workers learn many skills. All workers should be tested before assigned to specialized tasks to ensure they have the required skills. The workers will then be assigned to more tasks at a journeyman level and will receive a higher wage. Managers in the surveyed companies find it is difficult to train a worker in many skills during a single project. A typical construction project lasts less than three years, but it takes many more years to become knowledgeable in a single skill. Thus, the multiskilled worker is created through participation in many projects.

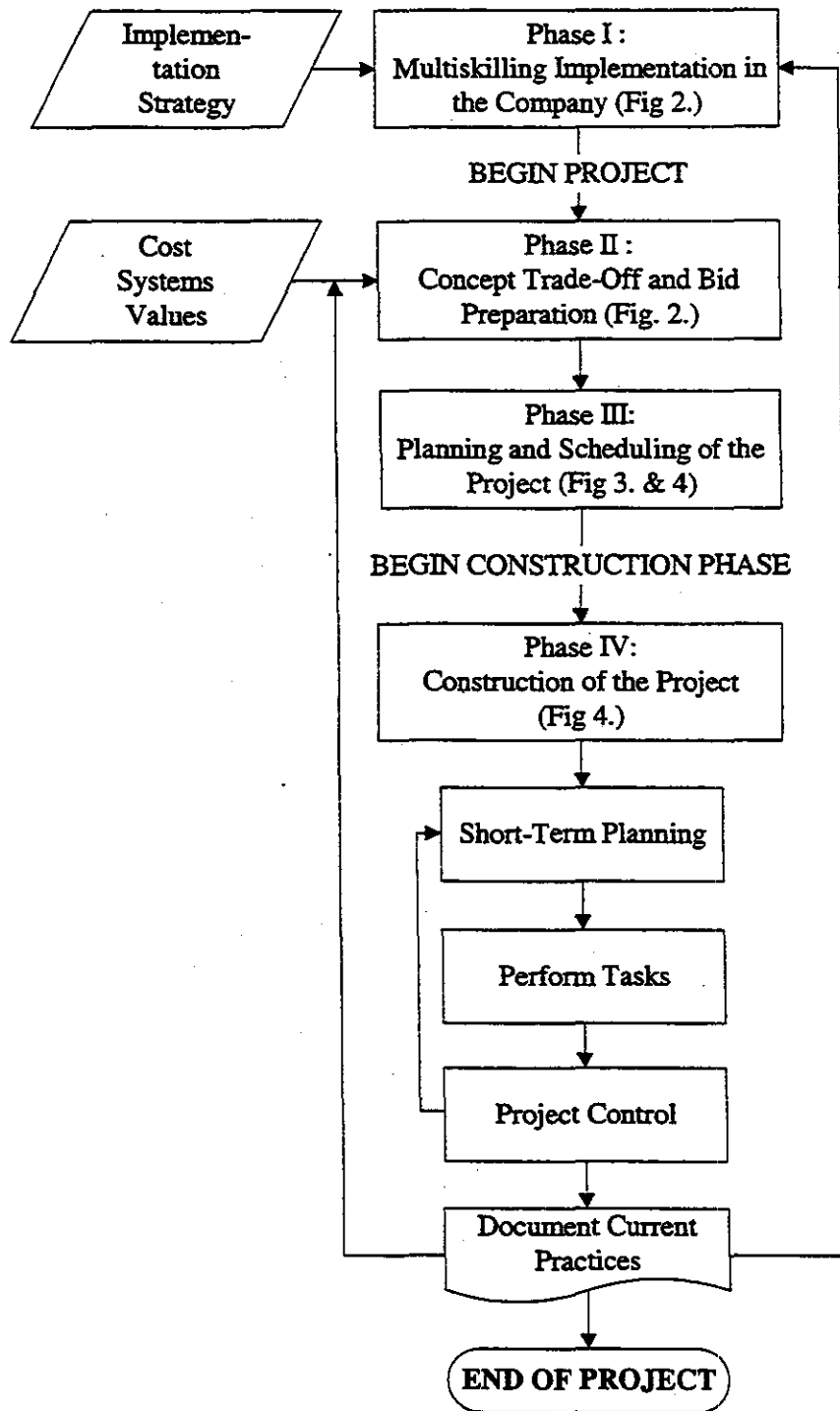


Figure 3.1. Summary Methodology for Planning and Scheduling a Multiskilled Workforce

A major benefit for the multiskilled worker is increased wage earning potential. The surveyed companies have established policies regarding wages for multiskilled workers. In 90% of these companies, when workers develop new skills their wages

increase. The compensation policy should be closely linked to the training and advancement of workers. Employee income is also increased through longer employment duration. A worker who is multiskilled can expect to work more hours during a given year than his non-multiskilled counterpart. As a result the worker will have a higher net income.

Even if highly skilled workers complete tasks where they do not use all their skills, they still receive the same hourly wage. To avoid high labor costs, managers try to avoid such cases. Instead, they assign simpler tasks to workers that are not highly skilled and are paid lower wages. All companies, however, assign simple tasks to highly skilled workers if there is not enough specialized work, as a mechanism to retain them in the company. This assignment may be a great cost for companies, but they consider it an investment that helps maintain an experienced workforce. When the multiskilled workforce is utilized properly, it should generate savings to the projects' labor costs although workers are earning higher wages by lower turnover, higher productivity, fewer accidents, and because fewer workers are required (Burleson 1997).

The surveyed companies hold that workers cannot be remunerated according to the tasks in which they participate. Companies recognize they have more skills and they should earn more because they will perform every activity based upon more knowledge. Companies believe the uncertainty in the total earned and the non-steady wage rate demotivates workers. Furthermore, keeping track of all the activities in which a multiskilled worker participates requires great effort on the part of project supervisors.

The skill categories that should be grouped together must be identified and standardized during the implementation of multiskilling in the company's culture. Standardizing the skills association facilitates the planning process because the tasks that are performed by each crew type become well identified. Skills are usually associated according to the basic duties they share. However, if electric, civil and mechanical trades are considered general trades, multiskilling may be done within those trades or across their boundaries. If multiskilling crosses boundaries, common skills should be identified as the general trade. By analyzing the typical skills' association schemes of the surveyed companies, it was concluded that there is no general standard for grouping skills'

categories. The skills are grouped depending on the type of projects the company develops.

During the implementation of multiskilling in the company's culture, it should be determined if this is the labor strategy that will be followed for all projects. This decision is made based on the benefits multiskilling may bring to the company and the types of projects the company develops. Some of the reasons that companies may consider when deciding to what extent multiskilling will be implemented in the workforce are available training, amount of specialized tasks, and stability of the workforce.

3.2 Phase II: Project Concept Trade-off and Bid Preparation

Figure 3.2 presents the steps that the company should follow to implement multiskilling at the project level after including multiskilling in the managerial scheme of the company. This implementation process includes the conception of the project with consideration given to multiskilling and the bid proposal developed presents its benefits.

If during the implementation of multiskilling in the company's culture multiskilling was not established as the unique labor strategy, the benefits and requirements of multiskilling need to be analyzed. Some of the factors that contractors consider when deciding whether to use multiskilling in a specific project are the knowledge the company has implementing multiskilling on these kind of projects, in-house or out-sourcing of workers, possible labor shortages, and project location from sources of labor workers. Additional factors such as unions' reaction to the implementation of multiskilling, owner's requirements, effect of the implementation of multiskilling on the company's image, and its relationship with owners and subcontractors should also be considered.

Project's owners specify in bid documents if they agree to the use of multiskilled workers. Occasionally, the company presents the benefits of multiskilling to the owners to obtain their support. In some projects owners do not agree with the implementation of multiskilling because they consider the projects only require the exclusive use of specialized workers to satisfy safety or quality concerns. The owner should mention these requirements on the bid documents. If the owner does not include in the bid document any special requirement regarding the labor strategy to follow and the project

will be performed through a cost-reimbursable contract, the owner may still discuss the benefits of multiskilling during the construction phase.

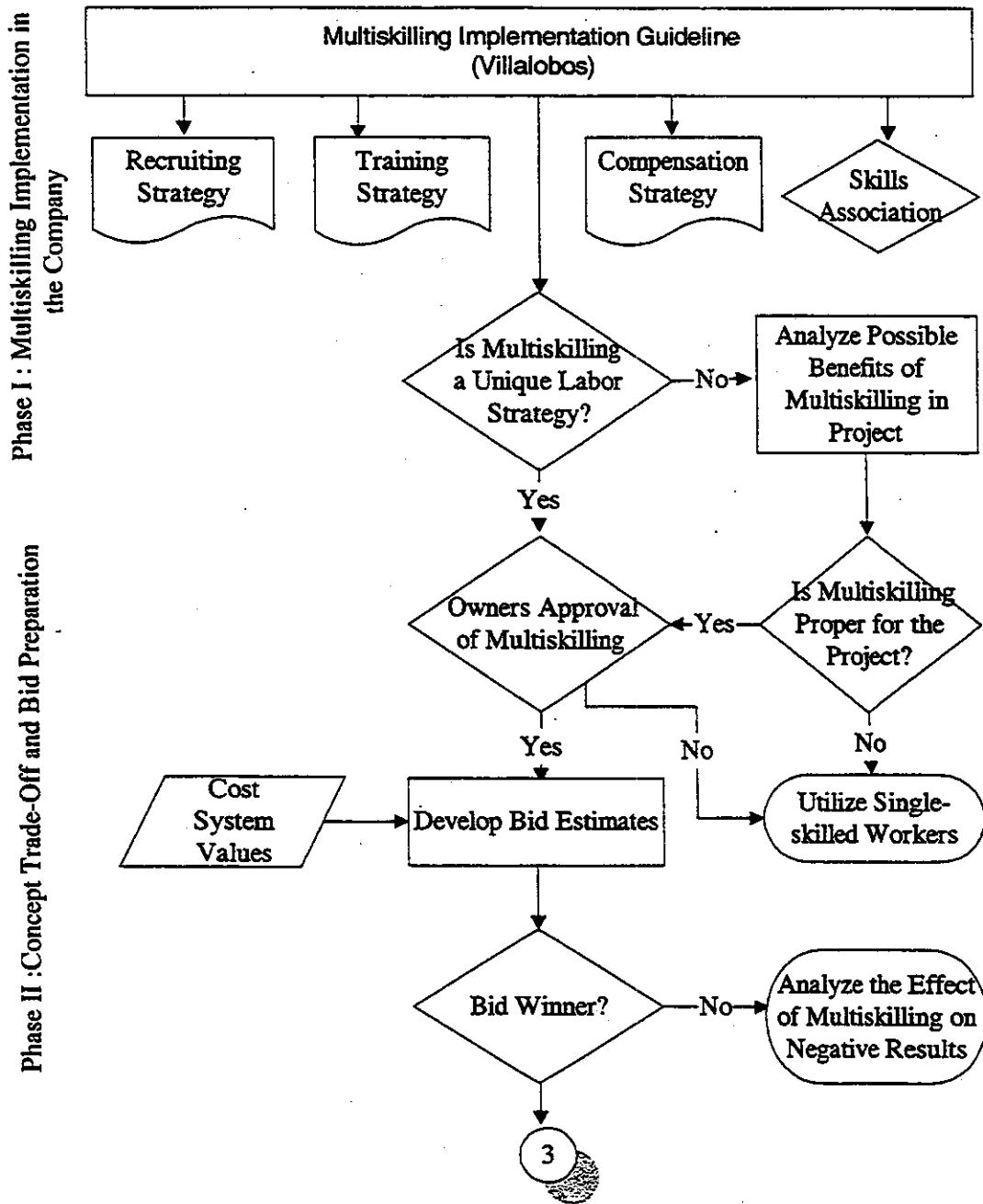


Figure 3.2. Implementation, Project Concept Trade-off, and Bid Preparation

The estimating process of a project where multiskilling is implemented does not differ from the estimating of a project where multiskilling is not implemented. The estimating of costs is done at the task level. Labor requirements are identified by a conventional method according to the skilled workers related to each task (i.e. one operator, one pile driver), and according to the activity's duration in work-hours. However, during the performance of the activity it may be that fewer workers or fewer transfers are required due to the skills they possess.

Estimates do not mention the use of multiskilled workers, the cost and time values used are obtained from previous experiences of the companies in similar projects or from standard estimating manuals. These values are adjusted according to the companies' experience and the engineer's criteria in which multiskilling is implicitly considered (Foster 1998). Surveyed companies claim that the final price for most activities is usually lower if using a multiskilled workforce, but there is no hard evidence to support this point. The interviewed estimators explained that the difference on price is because of the workforce performance. With a multiskilled workforce, an activity is usually accomplished in a shorter period of time possibly because workers are more efficient (Foster 1998; Varner 1998). Also, the same crew may conduct different portions of the work, instead of using many specialized crews. This saves time on changing crews, and there is no loss in productivity due to transition of personnel. All these benefits are reflected in the adjusted time values and unit rates that are utilized for developing the estimates.

If the company did not obtain the bid, it should be analyzed if its approach to multiskilling contributed to the loss of the bid. For example, if the labor strategy was not clearly presented, owners may not appreciate its benefits and perceive an unconvincing labor approach.

3.3 Phase III: Project's Planning and Scheduling Phase

Figure 3.3 presents a planning methodology for a multiskilled project. Multiskilling should be considered during this phase to ensure that plans are in accordance with the conditions under which the project will develop. The planning

methodology that is presented above is based on the Critical Path Method (CPM), because all the surveyed companies utilize it to reduce costs and to increase efficiency.

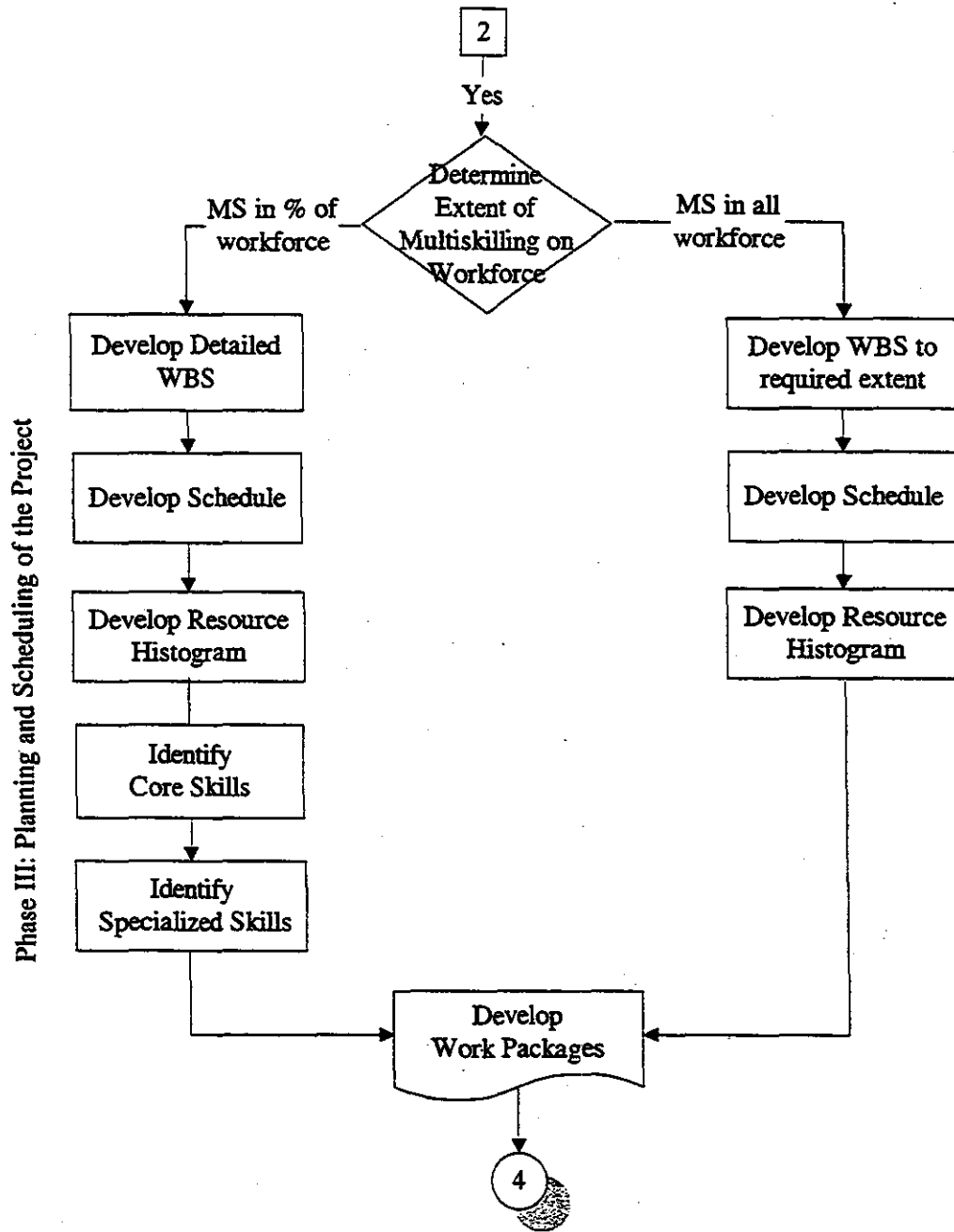


Figure 3.3. Planning and Scheduling of the Project

The first step on planning a multiskilled workforce is to determine its extent. As mentioned before, multiskilling may be implemented throughout the workforce or in a

certain percentage of it. The company's criteria and the project's characteristics determine the extent to which it should be implemented. Specialized workers are required for the projects that involve many skills that are not available in the multiskilled workforce. Training may also limit the extent of multiskilling in a workforce. If available workers are not multiskilled and the company has not designated adequate funds to develop more skills for its entire workforce, multiskilling is only based on the skills workers already possess.

In the planning phase, companies determine the activities that should be performed, and the scope of those activities. The tasks of a multiskilled project do not differ from those in a project that utilizes single skilled workers. A Work Breakdown Structure (WBS) identifies every task that should be performed, thus it should be developed even if the project's owner does not require it.

When a company's workforce is not composed solely of multiskilled workers but includes many single-skilled workers, the work should be broken down into small pieces, each piece or task involving a single skill. When the workforce is composed only by multiskilled workers, planners combine activities that involve certain types of work into a higher level activity and assign them to a specific crew. This crew has every skill required to perform the tasks. Planners attempt to profit from multiskilling by combining activities. If a single crew can perform all the tasks, there is less transition or idle time. The activities are grouped together according to their progression during normal construction processes. The planners explained:

For example, if logical progression on a site for concrete work is to have the carpenter be followed by the ironworker, who is followed by the carpenter (to strip forms), it would seem best to group all these skills together and have a crew that did the entire activity from start to finish. This will eradicate idle time from waiting for other crews to finish a part of the process" (Current Practice Surveys 1996).

A previous CII research effort entitled *Open Shop Construction Workers and Their Environment* mentions that workers may be motivated when allowed to complete natural units of work. The report suggests that a worker's job may be more meaningful by identifying basic work activities that can be combined together to create larger natural work units (CII 1990). Therefore, the activities should be combined in a fashion that ensures the assigned crews will have all the required skills and workers' motivation will

also increase. There is no documented or standardized methodology for identifying the best combination of activities. This is done according to the planners' experience and their knowledge of the workforce.

The duration of tasks is calculated utilizing quantity take-off values and productivity factors. If not all workers are multi-skilled is preferable to ignore any increase in productivity due to multiskilling. The duration of the activities is not calculated considering the composition of the crew that will perform the activities because this information is not available in the long-term scheduling phase of the project. However, if planners know that one single crew will perform all the activities without considering craft boundaries, they will load this crew with the total amount of required man-hours. The developed schedule should be adjusted during the short-term plans according to the time-savings that multiskilling may generate during the construction phase.

After identifying the duration and the skills associated with each task, the labor resource histogram is developed to ensure enough manpower to perform the project's activities. This is done by considering the amount of work to be performed and the man-hours available. The advantage that CPM brings to multiskilling is that labor resources can be loaded in the schedule.

Through the study of resource histograms, it is also possible to analyze the continuity of work for every crew, to review labor fluctuations and to identify the skills that are required from beginning to end in a project. When multiskilling is implemented as the core workforce of the project, it has these skills. Some of the skills may not be required continually but they may be associated with other skills that involve similar basic knowledge thus maintaining a constant workforce size. When a company utilizes a multiskilled workforce, the carpenter may be the same pipe fitter, but this fact is not considered when developing the resource histogram. All the surveyed companies count them as two separate workers because their combination of skills is not certain and because some companies also utilize single-skilled workers.

The resource histogram also evaluates how smooth the workforce transition will be. Planners attempt to create a smooth transition through software functions or manually. They assure continuity of job for each type of crew on the assumption that, as

the workers become multiskilled, they may participate in many tasks, at least at the helper level. In this manner, they are always working. The planners should identify the periods of time in which specialized workers are required. Because these workers perform a limited number of tasks, these tasks should be scheduled in sequence if possible to avoid constant hiring and firing. As an alternative to ensure work continuity, the multiskilled workers possess the skills required to perform some specialized tasks, which will reduce the need for additional workers and avoid learning curve losses.

The use of multiskilling avoids peaks and valleys in the resource histogram, and reduces the final costs of the project (Burlleson 1998). Surveyed companies believe that it is cost-effective to have a constant workforce through the entire project, even though it may affect the date of completion because it reduces the costs associated with hiring and firing workers. The managers of these companies may suggest this approach to owners as a strategy to reduce costs; owners frequently accept this recommendation unless the project is time-cost driven.

After developing the master schedule and adjust it to the labor requirements, planners prepare the Work Packages (WP) to be utilized during the construction phase. The WP should include the work scope, the basic schedule, materials, and the list of skills required for each activity. The crew mix may be deduced from this list of skills. Work Packages are not a requirement of multiskilling. The utilization of this technique is suggested because the surveyed companies believe it is an effective tool to provide foremen with all the information relevant to the constructive processes. Nevertheless, alternative information systems may be utilized according to the company's policies.

Figure 3.4 presents the following steps of the planning process for a multiskilled workforce. Planners identify the skill mix necessary in the project's workforce based upon what skills are required to perform the project's tasks. The period of time in which these skills are required is also defined, according to the master schedule. The staffing department is informed of labor requirements and is responsible for ensuring that the workforce will include the required skills. The staffing department determines if the company's available workforce is enough to satisfy the project's labor requirements. If new workers should be hired, the recruiting strategy should be followed. The project is staffed with workers that are transferred from other projects and the newly hired workers.

The workforce's skills and size should satisfy the project's requirements that were identified during the planning process.

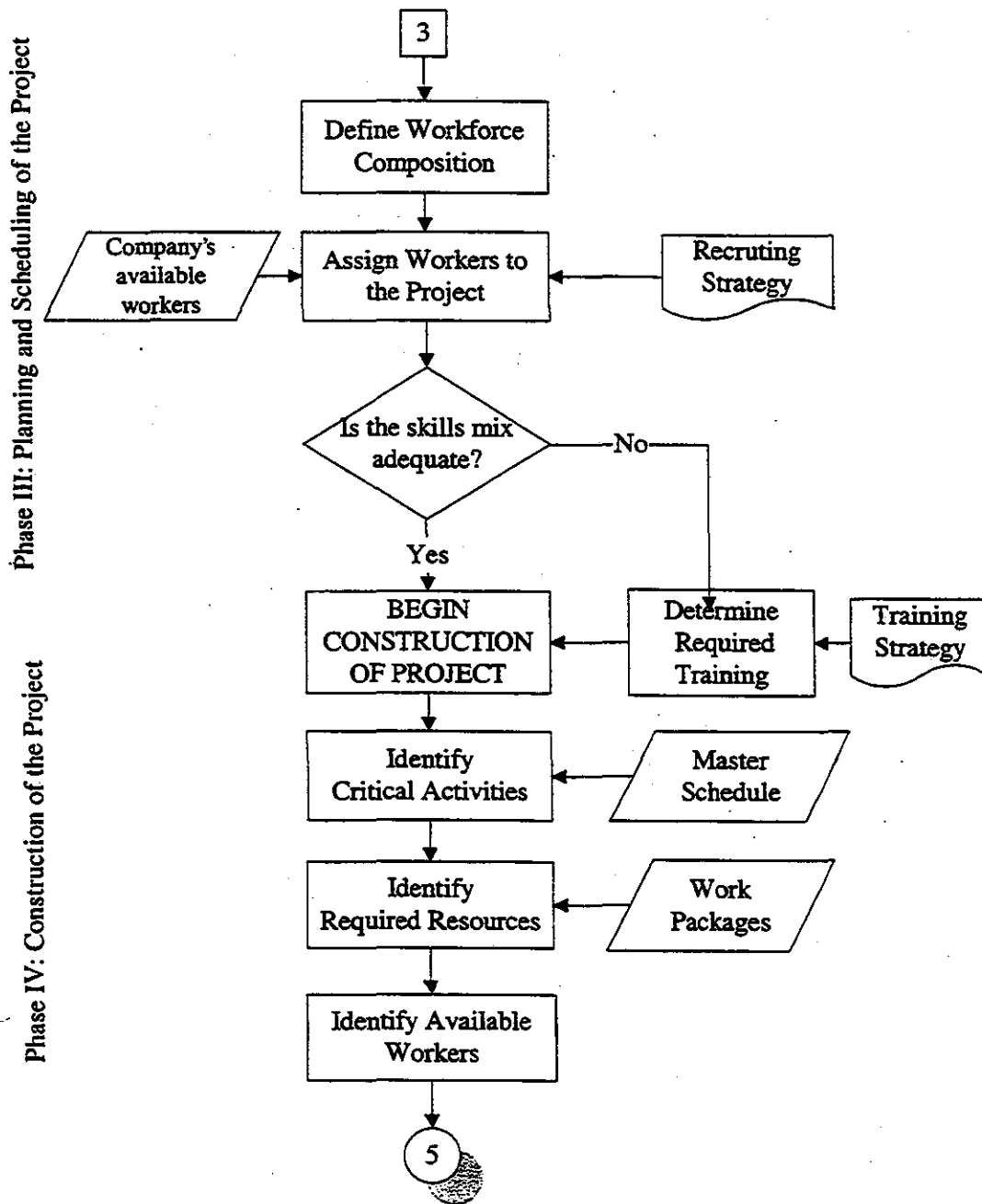


Figure 3.4. Planning, and Construction of the Project

3.4 Phase IV: Construction Phase

It is during the construction of the project that the benefits of the multiskilled workforce are perceived. Although an adequate planning process is the basis for a proper performance, the project performance depends on the management of all resources during the construction phase. Figure 3.5 presents the steps that a company should follow during the construction of the project, to achieve the better utilization of the multiskilled workforce.

During the short-term plans, crew composition is determined according to the skills required to perform tasks to which the crew will be assigned; these skills are identified during the planning phase. There are great differences between the crew composition process for a multiskilled and a single-skilled crew. In a single-skilled crew, the civil work should be broken down into smaller pieces. For example, the cement finisher crew, the carpenter crew, etc. That gives the planners more work because they must make certain tasks are scheduled properly to avoid losing time changing and mobilizing crews. The crew composition is constant throughout the project because it includes a unique skill. A foreman is included in each of the single-skilled crews, and works with his or her people all the time (Stevens 1998).

In a multiskilled environment, a crew may be composed solely of highly skilled workers, each of them proficient in a different craft. During the performance of each activity one of them who is highly skilled in that activity leads the job. Less skilled workers are assigned as helpers, and they learn from the jobs they perform. The following is an example of this approach: Planners have identified that certain tasks require five pipefitters and five instrument fitters. The pipe fitters' skills are needed at the beginning of tasks, but are not required later. The opposite happens with the instrument fitters' skills. Thus, both skills are combined, and the trades help each other. This is possible because both trades share many skills. If the company is an open shop, workers usually agree participating on tasks out of their trade because they want to keep their job (Anderson 1998). On the other hand, unionized workers are trained in more than one skill within their trades and may be specialized in only one of them. They will be willing to cooperate in any tasks within their trade, however.

Phase IV: Construction of the Project

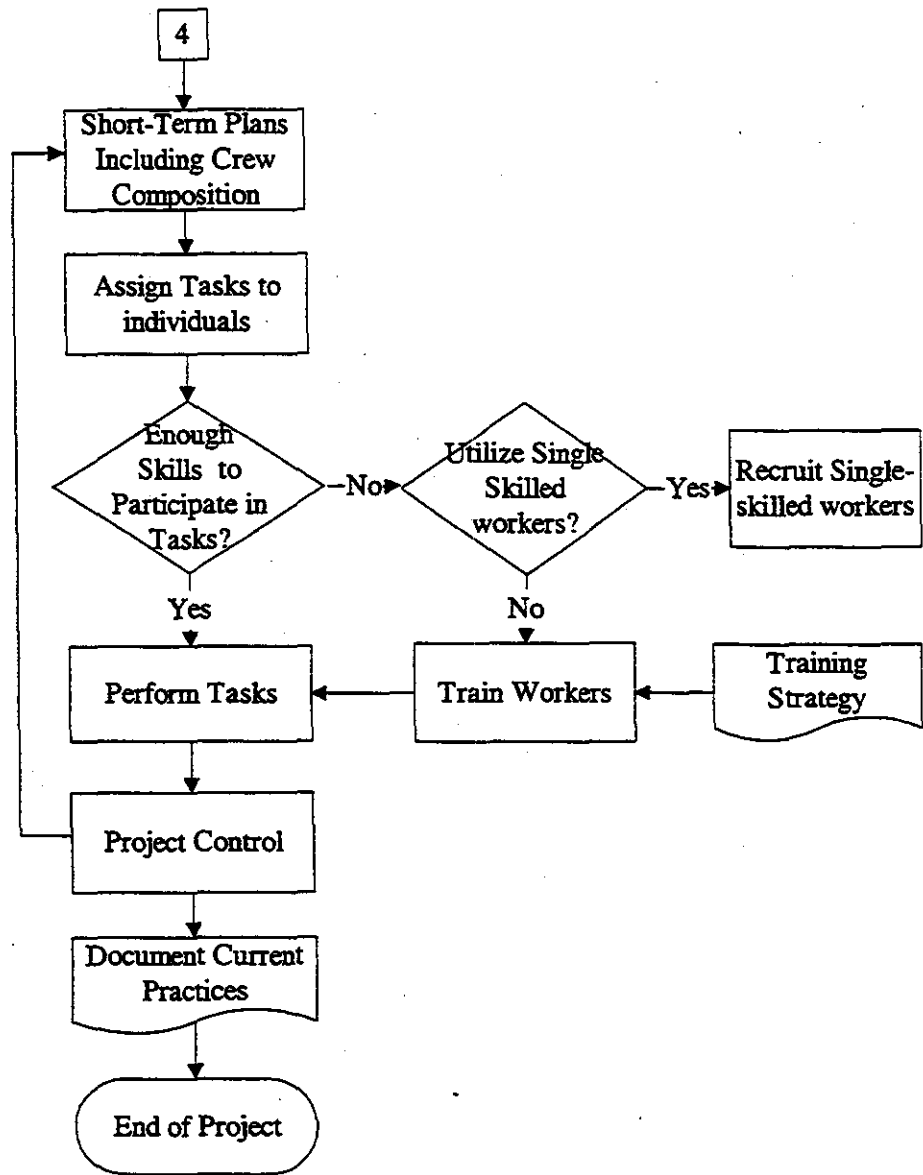


Figure 3.5. Construction of the Project

The planned crew composition that is included in the WP may not correspond to the project's requirements or to what workers are available. The foreman evaluates the planned crew mix and adjusts it accordingly. The planned sequence of activities may be modified during the construction phase by the foremen to optimally use crews and equipment or to maintain good workers on the project.

The foreman determines how to compose crews according to the skills of available workers and the tasks' requirements. Workers may be proficient in many skills, but foremen will try to assign them to the tasks in which they are most knowledgeable. Some workers may not work in their main crafts if these are not required in the coming days, but they may be assigned to other crews if they possess the basic knowledge to act as helpers. The role that each member of the crew plays when performing the activities is determined by the skills they possess. The skill mix within a crew ensures that the tasks are performed as required.

Foremen assign tasks according to their knowledge of the workers and the project's conditions. Foremen know their people and use this knowledge to create crews and assign workers to tasks in which they will be more productive (Verner 1998). Although all the surveyed companies have implemented databases that keep information about workers' skills, none of them have developed an information system to help foremen identify the best workers for each task. Fifty percent of the companies acknowledged that the foremen utilize the databases to remember workers' skills, though this is not the main function of the databases. Furthermore, they admitted that not all foremen know how to access the database and that the information on it could improve the crew composition process. Some managers suggested that the company had not considered the benefits of foremen's access to the database, or feared sharing information about workers due to the confidential nature of some information (Anderson 1998).

During the crew composition process, if the foreman finds that there are not enough highly skilled workers to perform required tasks, he or she may suggest the company training some workers to satisfy the project's requirements. The foreman may also convince some workers to be trained if the foreman wants to keep them on the project even though their particular crafts are no longer required. If the foreman concludes that available workers cannot satisfy the labor demand, new workers are hired.

By analyzing the crew composition process, it may be concluded that the advantages of multiskilling are obtained through the short-term plans, mainly making good use of the many skills workers possess to shift them around the activities. Although some companies link tasks that involve similar crafts together, the advantages of multiskilling are obtained through the crew composition process; it depends solely on the foremen's capabilities and knowledge. This limits the effectiveness of the crew composition because many important issues may not be remembered. For example, things like how proficient workers are at certain crafts, or their experience on a similar project needs to be remembered (Denisson 1998). Furthermore, composing crews based on the foremen's criteria is a very subjective process, and does not guarantee that workers are assigned in the most productive manner (Anderson 1998).

Through the short-term plans, foremen identify which workers are required in future days and which workers will finish their tasks soon. Foremen analyze if multiskilled workers can be assigned to other tasks where they might help satisfy the demand for new workers (Anderson 1998). If the workforce should be reduced (ROF), the best workers are kept. One criterion for choosing which workers stay in the company is the number of skills workers possess. If a foreman is interested in keeping certain workers he or she will suggest they get trained to develop skills that will be required in the coming stages of the project (Dolce 1998).

Workforce performance is controlled by the work hours required for each activity. Project engineers control on-time completion of activities, according to the master schedule. An accurate cost control system identifies whether the project requires too many or too few men-hours, or if it requires workers with wages that are too high, in accordance with approved estimates. The data that is gathered through control mechanisms should be filed and utilized as a reference for the development of estimates, plans and schedules for future projects. This information is based on the performance of a project where multiskilling was implemented. Thus, its application ensures that future projects will be conceived considering multiskilling from the initial phases.

Surveyed companies believe their projects are usually finished on time because of their planning efforts, not necessarily because of multiskilling. They accept that this labor strategy benefits the project performance because workers are committed to their

jobs and getting them done on time. Workers are more productive, and there is less idle time. Nevertheless, these benefits would not be realized without an accurate planning process that ensures all the resources are available on time, all tasks are clearly identified and in general, that the project will be developed properly (Susi 1998).

The data that is gathered through control mechanisms should be filed and utilized as a reference for the development of estimates, plans and schedules for future projects. This information is based on the performance of a project where multiskilling was implemented. Thus, its application ensures that future projects will be conceived considering multiskilling from the initial phases. This knowledge should be included in a future-consulting document of Lessons Learned.

CHAPTER 4: NEED FOR TOOLS THAT SUPPORT THE CREW COMPOSITION PROCESS

The surveyed companies have developed databases that keep the work histories of current and past employees. The function of this database is to record, in an organized fashion, the capabilities of individual workers. The personnel department consults the databases when assigning people to projects according to their skills, location, and former experiences with the company. The database does not maintain information about skill levels or how proficient a worker is in a craft. A database supports the growth of a multiskilled workforce because workers with more than one skill may be identified during the hiring process (Nixon 1998). The surveyed companies prefer to hire multiskilled workers, though they may be initially hired for one specific craft. If workers have additional skills they may be assigned to other crafts, keeping them on the project.

Planners and foremen do not consult the databases, though they should know the workers' skills to be able to assign them to proper tasks. None of the surveyed companies possess a computerized information system that generates crews' compositions or automatically suggests the most appropriate workers for certain tasks based on their background and skills. Companies give foremen the responsibility of assigning workers in a proper manner without the help of this system. Foremen have experience managing workers in an efficient manner and should be able to do this with ease. Companies believe that it will be efficient to combine the planning and scheduling processes with the crew composition process, but they believe this approach may be extremely expensive since it requires constant communication among all parties. A good planning system might be based on the company's database and should be easy to access.

Managers and craft workers interviewed at visited companies confirmed that implementing a multiskilled workforce facilitates more productive work. It saves time and money and reduces the total number of required workers on a project, decreases transfers, and allows the best distribution of skills. The efficiency of the work performed is usually measured in terms of achieving low total costs or meeting the scheduling timetable (Brusco 1996). No formal measure of the efficiency of any crew composition

is available; i.e. how many transfers were avoided. So it is not possible to assure how efficient is the process that is being actually followed to schedule a multiskilled workforce.

The management of human resources involves issues that may not be represented in a mathematical model or in computer software, since they are based in the nature of human beings. For example, a model cannot consider if a worker likes or dislikes performing certain activity when assigning tasks, if certain crew composition includes workers that are not productive when working together. Present research findings conclude that these issues actually lead the manner in which a multiskilled workforce is managed. Utilizing computer software to assist in the crew composition does not mean that the issues not represented on it will not be considered when composing a crew. Rather, all the possible solutions must be considered and then managers should decide which one is the most appropriate, according to all the objectives of the project. This research effort, then, suggests the development of computer software to assist in the crew composition and project staffing process. It would be a tool to support managers on taking decisions and ensure gaining the maximum benefits from multiskilling.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The following conclusions emerged from this research effort:

- 1. The surveyed companies have implemented multiskilling primarily to reduce their labor costs.** Their intention is to implement this labor strategy in most of their projects. This labor strategy is an excellent alternative for maintenance projects, due to the broad variety of tasks that should be performed by the same workforce. It also represents benefits for any type of construction projects.
- 2. Considering multiskilling during all the phases of the project increases its advantages.** It should only be implemented in a project after it becomes a part of the company's managerial scheme and after training, recruiting, and compensation strategies have been determined. The multiskilled workforce should be planned properly to maximize time spent on site by workers, reduce labor requirements, and ensure it includes the skills' required by the project. If experience on multiskilled projects indicates a percentage of labor savings, a factor could be utilized to bid future works at a lower cost to be more competitive than contractors utilizing traditional single-skilled labor strategy.
- 3. The success of multiskilling greatly relies on the foreman's ability to assign workers to appropriate tasks and compose crews effectively.** The foreman assigns tasks to workers according to what he or she knows about them and their capabilities as well as his or her own experience on former projects.

4. Surveyed companies possess a simple database which contains the information regarding the skills and experience that the workers possess that is rarely consulted when the crews are composed.

5. The process followed by the visited companies when organizing the workforce can be improved by optimizing allocation of workers.

5.2 Recommendations for Future Work

The following recommendations emerged after documenting the current practices in the surveyed companies, and identifying the specific requirements of a multiskilled workforce:

1. Foremen should consult the company's database as a tool to recall the workers' capabilities.
2. Develop computer software to assist in the crew composition and project staffing process and ensure the optimum allocation of workers according to some specific objectives such as minimize transfers, reduce labor costs, maximize workers' time on a project, or reduce the workforce size.
3. Multiskilling avoids craft jurisdiction by assigning tasks to workers according to their abilities and the project's needs, not according to their affiliation. Therefore, unions may resist the implementation of this labor strategy, but agreements with labor unions may be established to broaden the working area of their members. An in-depth study of the special characteristics of construction unions and construction contractors should be conducted before suggesting an appropriate mechanism for gaining the unions' support to multiskilling and enable the utilization of multiskilling in all areas of the construction industry.

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APPENDIX B: INTERVIEWS

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