REQUIREMENTS AND BARRIERS TO ADOPTION OF LAST PLANNER COMPUTER TOOLS

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ABSTRACT

The Last Planner methodology has been applied to construction and design. These efforts have resulted in the development of computer programs (WorkPlan and DePlan) that guide production units in creating reliable work plans. One of these programs was extended to include distributed planning and coordination and space scheduling capabilities as well (WorkMovePlan).

During and after the development of these tools, LCI member companies used them and provided valuable feedback. Some of these companies have developed in-house spreadsheet applications to meet their own particular needs. These beta-testers were familiar with the Last Planner concepts, which allowed them to make suggestions based on their conception of the Last Planner methodology.

This paper reports on the feedback from the beta-testers of WorkPlan, DePlan, and WorkMovePlan. This feedback provided a foundation for further specifying requirements for the Last Planner computer tools. The paper also discusses barriers to adoption of Last Planner tools in companies that are new to lean construction and in companies that have already started lean transformation. These findings not only assist in improving existing tools but also reveal new areas for computer tool implementation.

KEYWORDS

Last Planner methodology, lean construction, design management, construction management, production management, computer tools, distributed planning, coordination, planning, scheduling, space scheduling, WorkPlan, DePlan, WorkMovePlan, work package, assignment.

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INTRODUCTION

Application of the Last Planner methodology to construction and design has resulted in the development of WorkPlan (Choo et al. 1998, 1999) and DePlan (Hammond et al. 2000), respectively (Figure 1). These tools guide production units in following the Last Planner methodology to create reliable work plans.

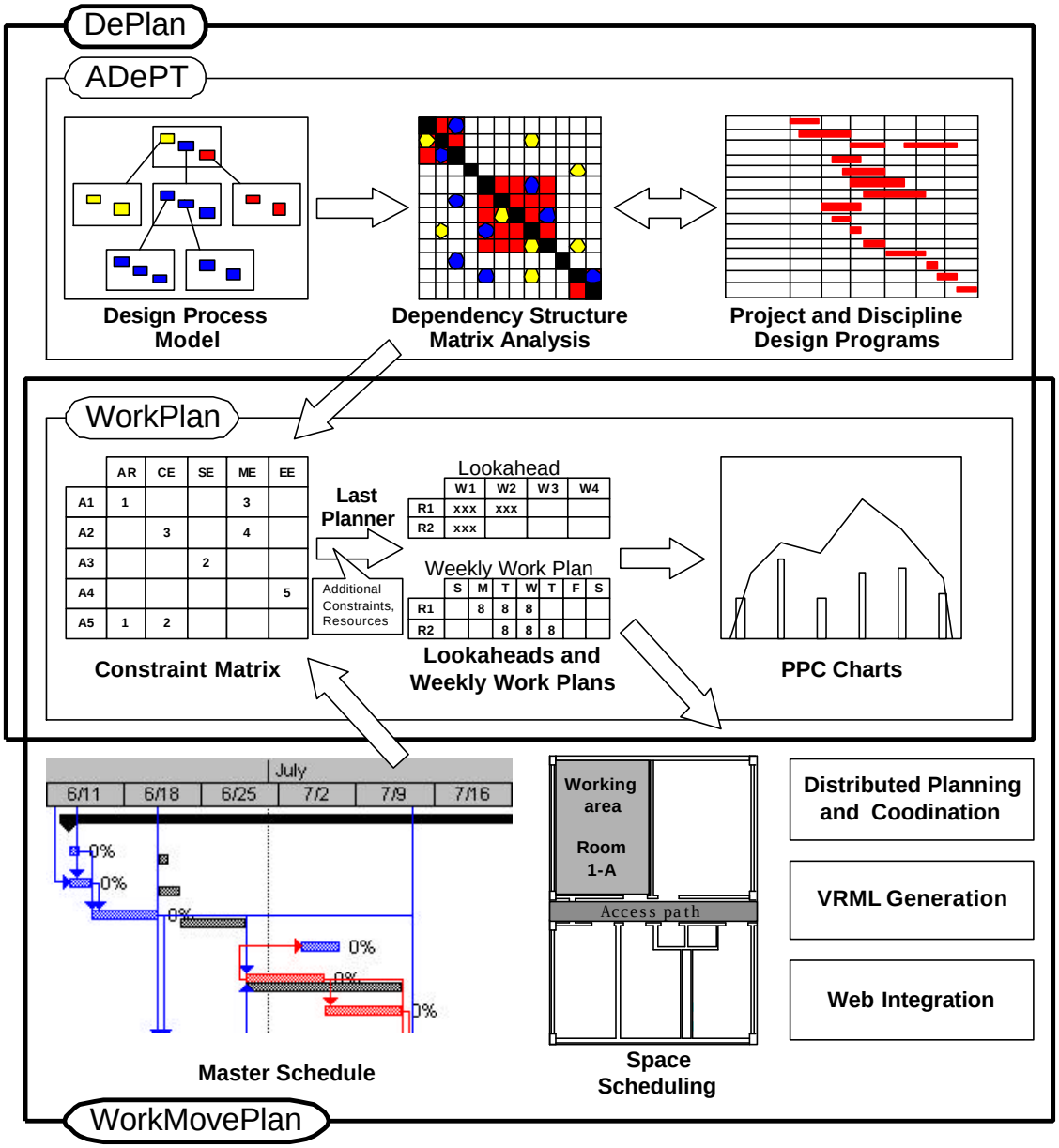

Figure 1: Last Planner Software including WorkPlan and WorkMovePlan

WorkPlan is for specialty contractors to develop weekly work plans. WorkPlan is a stand-alone program but it also allows for production units working on construction projects to import basic schedule information, such as a list of activities, precedence relationships, etc. from Microsoft Project (Microsoft Corporation 2000). DePlan combines WorkPlan

with ADePT's (Austin et al. 1999) ability to represent design process models, perform dependency structure matrix analysis, and develop design programs for the overall projects and individual disciplines. DePlan guides production units working on design projects to import schedule information from ADePT.

WorkPlan has been extended into WorkMovePlan (Figure 1), which includes capabilities for distributed planning and coordination and space scheduling (Choo and Tommelein 1999, 2000a, 2000b). The distributed planning and coordination capabilities allow production units to increase the reliability of their plans by sharing work package, space scheduling information, and constraint information. The space scheduling capabilities allow each planner to explicitly allocate space, including workspaces, laydown areas, storage areas, and access paths.

After the development of WorkPlan, DePlan, and WorkMovePlan, beta-testers from four member companies of the Lean Construction Institute (LCI) (Pacific Contracting, Barnes Construction, Oscar J. Boldt Construction, and Gowan Inc.) and academic institutions (Loughborough University in the U.K. and Universidad Catolica de Chile) provided feedback and recommendations on their use. The beta-tests took anywhere from one day to two months. The beta-testers knew the Last Planner methodology, especially the part related to weekly work planning. Some of them had developed in-house spreadsheet applications to support the Last Planner process given their own specific needs. These applications did not necessarily meet all their needs but they provided a temporary solution. However, the main advantages of these spreadsheet tools were simplicity of interface and ease of use. The beta-testers had wish lists expressing additional, desired features. Their feedback on our tools ranged from suggestions regarding adding and deleting fields in forms and reports (sometimes to make the forms and reports resemble their own), to changing how the tools should be used or what additional capabilities they should have (implementing their own wish lists). Having understood the Last Planner methodology and having been involved in creating their own tools allowed them to focus on making suggestions on how to improve the tools, rather than needing to be convinced to adopt the Last Planner process. However, their previous knowledge of the Last Planner prevented them from assessing how well this methodology was embedded and enforced in the tools. Enforcement would be particularly helpful to newcomers who are learning to follow the Last Planner methodology.

The real challenge for the tools is to be accepted by both newcomers as well as champions of the Last Planner. Whether the tools could be used to introduce newcomers not only to the Last Planner methodology but also to lean construction remains to be seen. This paper summarizes the responses and feedback received from the beta-testers, it further specifies requirements for the Last Planner computer tools, and it describes barriers encountered when applying these tools.

FEEDBACK ON IMPLEMENTATION

During the development of WorkPlan, Glenn Ballard (developer of the Last Planner) and Todd Zabelle of Pacific Contracting (a specialty contracting firm) provided valuable input to the authors regarding the planning process as well as the functional requirements for the development of software. As the Last Planner methodology itself was (and still is) evolving during the development, WorkPlan took on many different forms as well.

WORK PACKAGE VS. ASSIGNMENT

A key decision to be made during the first implementation phase is whether or not to adopt "work package" as a scheduling unit. The primary reason for adopting work package rather than a more detailed, smaller unit of work, was to prevent general contractors from micro-managing specialty contractors. The specialty contractor's concern was "if we give them too detailed a schedule, we end up creating smaller milestones for ourselves and lose the flexibility to do the job as we would like to." Although the term work package has not survived the conceptual evolution of the Last Planner, it is still an intricate part of WorkPlan, DePlan, and WorkMovePlan.

A closer observation of the primary reason for adopting work package reveals its usefulness. The weekly work planning effort to manage production units was complicated by the need to report weekly work plans to general contractors. In order to prevent micro-management, creating big enough units of work to hide detailed processes seemed reasonable. However, if a work package is too big, it does not satisfy the sizing criterion of the Last Planner (Ballard 1997). It also makes managing a production unit less effective. This finding led to formulating an important requirement specifically for distributed planning and coordination: the size of work for work planning does not necessarily have to match the size of work for reporting. Consequently, WorkMovePlan (which tackles distributed planning and coordination—note that WorkPlan and DePlan do not) incorporates a hierarchical work package structure.

In the current Last Planner methodology, resource assignments are made at the assignment level. It is therefore necessary to maintain links between two distinctively-sized units of works, namely work packages and assignments. These links, shown in Figure 2, maintain the relationship between the project schedule and the production schedule. Work packages refer to work that is assigned (or contracted for) by a general contractor to a specialty contractor. The specialty contractor can then break these work packages down into one or more assignments using the Activity Definition Model (ADM). However, this breakdown may be made visible or invisible depending on the specialty contractor's willingness to share that information. When the breakdown is made invisible, it is presented to the general contractor as aggregated data.

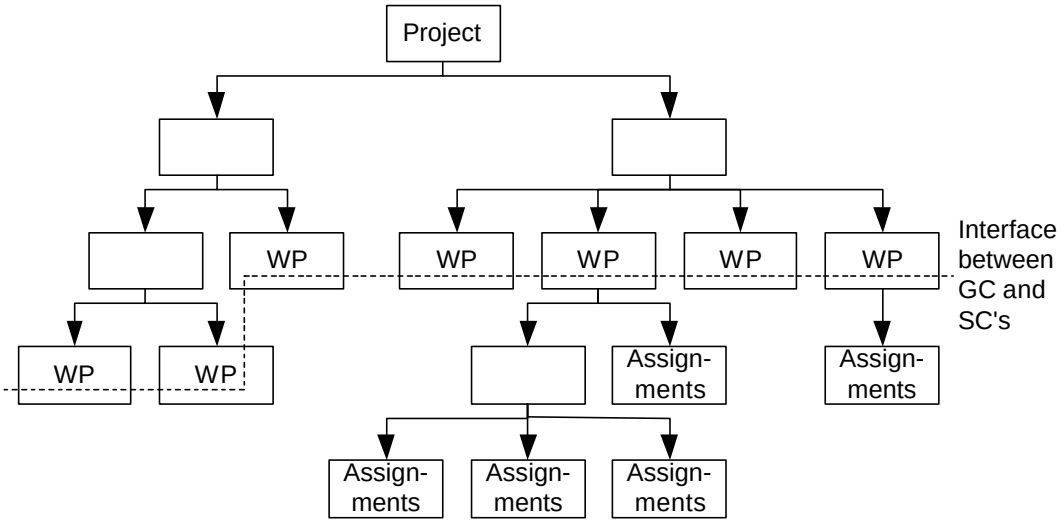

Figure 2: Relationship between work packages and assignments

Ballard (1997) uses lookahead schedules to link the project schedule to weekly work plans. However, maintaining an explicit link between these three requires effort. Different people use different tools to develop these schedules. Typically, project managers develop project schedules using CPM-based scheduling tools; superintendents develop lookaheads using either scheduling tools or spreadsheets; and specialty-contractor foremen develop weekly work plans using spreadsheets or mere crib sheets. Any of these may be done on a computer. Currently no single data repository or tool exists to support such different levels of scheduling by different people. A project manager who applied the Last Planner methodology to his project identified the need for explicit links:

> "We have convinced our subcontractors to tell us what they can do rather than give us an unrealistic schedule. However, one subcontractor is right now delaying our completion date. So we informed him that he was delaying the completion date and would be charged a penalty accordingly. However, he came back and told us that he could not be held responsible because he just did what he was told, i.e., "tell us what you *can* do [according to the Last Planner concept: what is on your weekly work plan and what is your workable backlog?]."
>
> In the first week on the project, this subcontractor did not know the Last Planner and he submitted a schedule as usual showing what he *should* be doing, namely complete four walls in a week. He ended up completing only half of what he had said he was going to complete that week. So we sat down with him to develop the following week's weekly work plan, with as aim to increase his planning reliability (PPC). He committed to completing two walls. However, it was unclear what effect this change would have on the total project duration until last week, when we updated the master schedule. It would be great if somehow the weekly work plans were linked to the master schedule."

When we shared this case with other planners, the most common and immediate response was "The duration should have been set in the contract." This contracting mentality does not create an environment where information can be shared freely. All too often, information regarding failure to meet a schedule then is withheld until the last moment, when it is too late to respond or inform others of the delays. In some cases, the schedule in the contract is purely for contracting purposes and it is never enforced. A project engineer on a building project presented this case:

> "Completion of the building is going to be delayed by one subcontractor. They submitted a schedule to finish their portion of work within a month because that was the duration set forth by the owner's master schedule. But there is no way they can finish that work in a month. They know it and we know it. So the schedule used for contracting sits in the cabinet and we use another schedule developed by our superintendent."

Contracting is not an effective means to coordinate the work of specialty contractors. A hierarchical distributed planning system that effectively links project planning with production planning helps to effectively coordinate specialty contractors.

HOW TOOLS CAN BE USED

Ballard (2000) and Fischer et al. (2000) report that most coordination-meeting time is currently spent on collecting information about the past and future, rather than on planning, i.e., figuring out the collective execution plan for the future. Some project participants are consciously trying to decrease meeting time spent on data collection.

On one project, the project manager (or the project engineer) talks to each specialty contractor in advance of the meeting, collects data, and types it into the scheduling program. The coordination meeting is then spent on informing others of the decisions made by each specialty contractor and identifying potential conflicts. Conflicts then can be resolved in separate, focused meetings involving only the affected parties. In this case, the coordination meeting is carried out at a relatively fast pace to keep all participants involved. To facilitate the meeting, a spreadsheet containing current and next week's weekly work plans is projected onto a screen. This spreadsheet allows the participants to view the latest information, point out errors, and add and delete information as necessary. However, the project manager found that he was spending too much of his time inputting, copying, and pasting information from last week's work plans to the next week's work plans. Most of these activities have been automated in WorkMovePlan. The project manager and project engineer requested that WorkMovePlan be designed to support both, planning by a single planner and planning during coordination meetings.

Several project managers requested that the graphical user interface (GUI) of the tools resemble what they were used to seeing, i.e., a Microsoft Excel-like format rather than a complex form view. In response, a new GUI for the "Work Package Constraints" analysis screen (Figure 3) and other GUIs have been added. As the non-Excel-like view (Figure 4) is complementary rather than obsolete, both screens now co-exist in the program. In DePlan, the "Constraint Matrix Screen" (Figure 5) enables planners to see in a concise format the number of outstanding constraints for the whole project. Clicking on a number in a box brings up the detailed list of constraints (not shown). Similar changes were made to key interfaces, such as the "Resource Assignment Screen" (not shown). Where appropriate, old GUIs were replaced with this new Excel-like format.

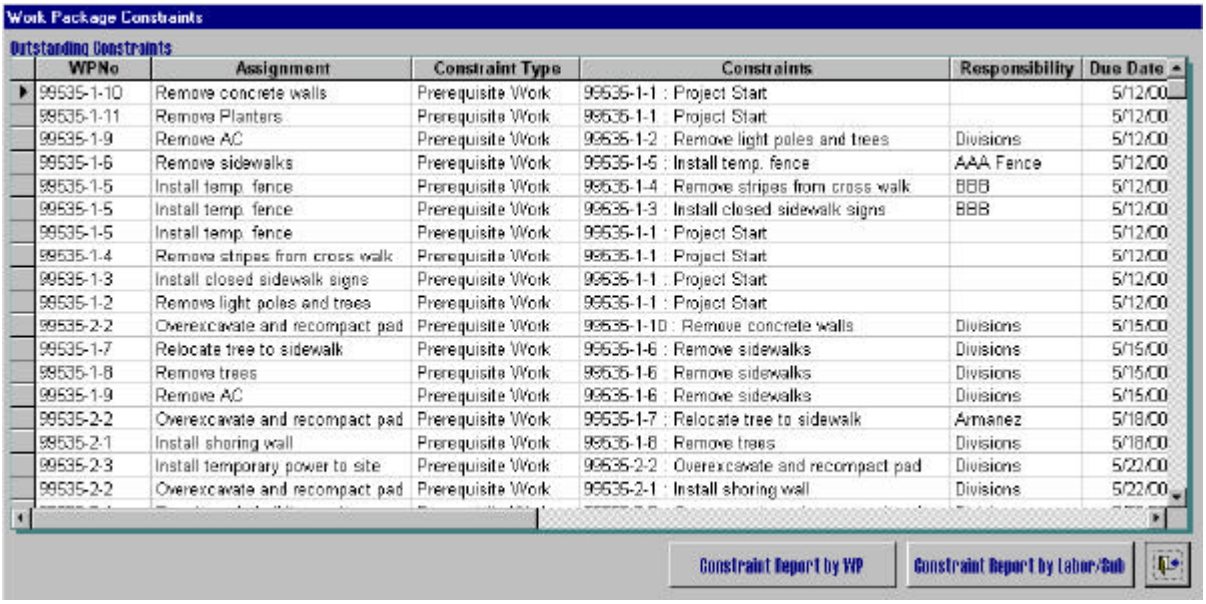

Figure 3: New GUI for Work Package Constraint Analysis Screen

One project manager provided important feedback related to the distribution of information. He requested that once constraint analysis and weekly work planning is done, WorkPlan, DePlan, and WorkMovePlan would automatically categorize the information according to the responsible parties and then generate reports to send in electronic format or to print and hand out as hardcopies.

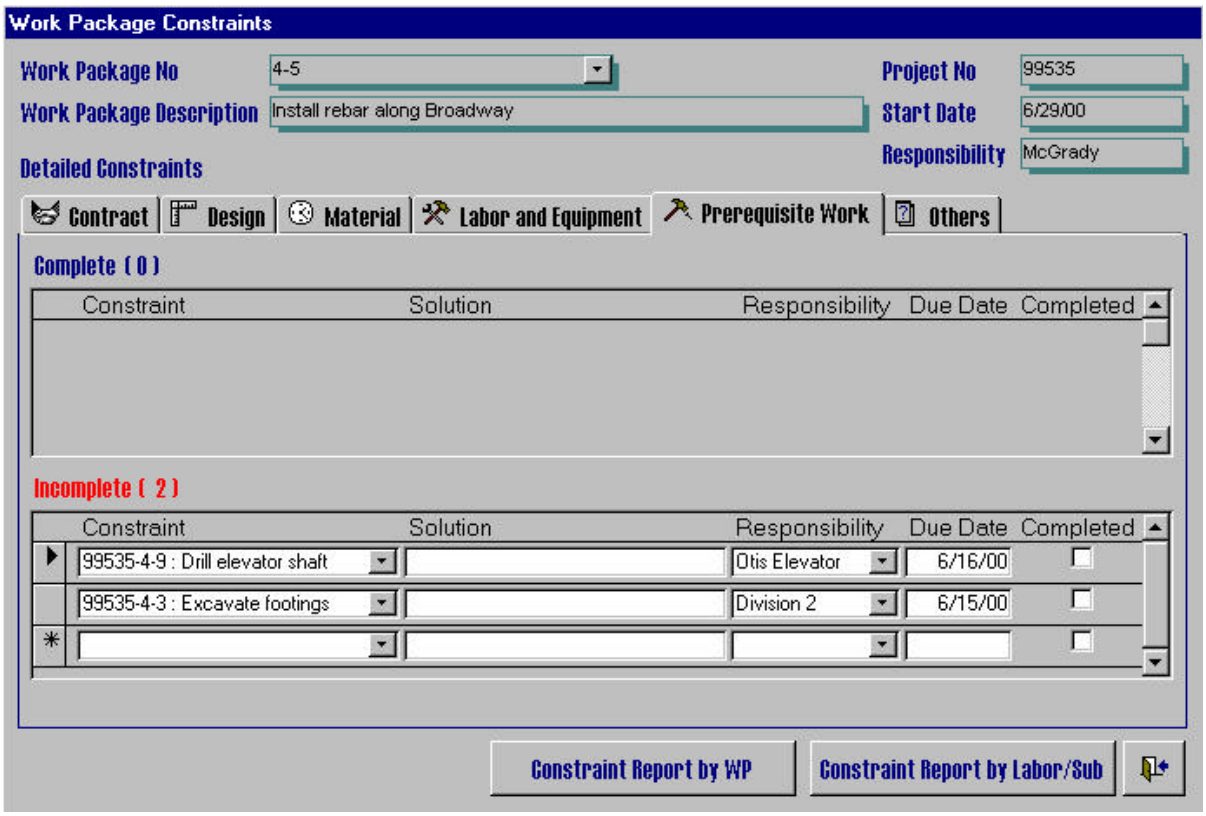

Figure 4: Non-Excel-like GUI for Constraint Analysis

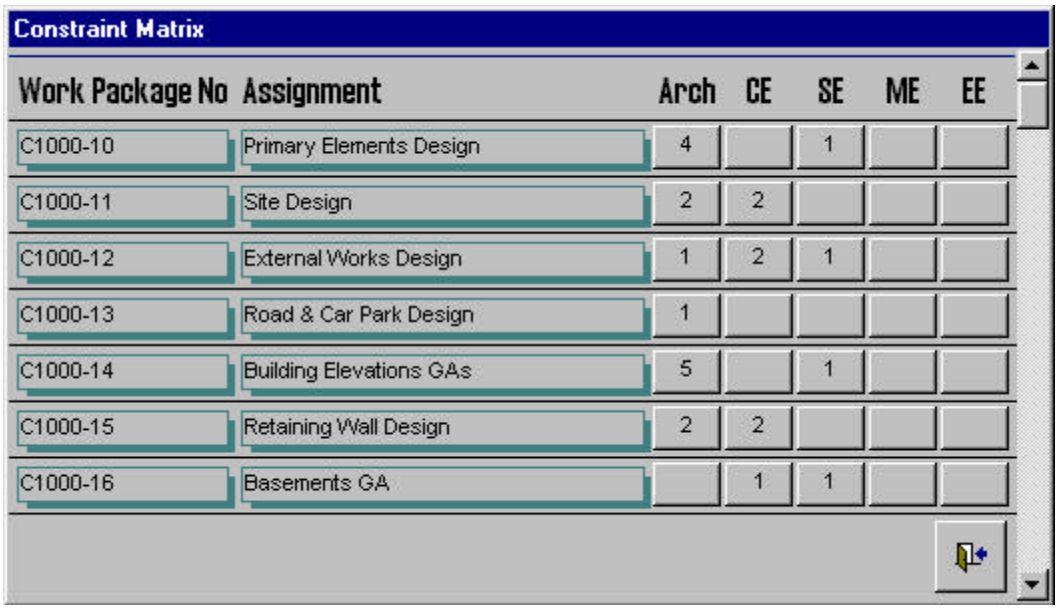

Figure 5: Constraint Matrix Screen

He wanted to have an efficient way to distribute the constraints to each responsible party or person right after the coordination meeting. Specifically, he requested that the planner would be able to generate reports from the constraint list, categorized by work package and responsibility. The new buttons to generate these reports are shown in Figures 3 and 4. The "Constraint Report by Work Packages" (Figure 6) allows the planner to see all outstanding constraints for a single work package. The "Constraint Report by Responsibility" (Figure 7) prints out a separate page with outstanding constraints for each responsible party.

Many other suggestions related to additional fields were made, such as adding a responsible party to each work package and so on. Some suggested functions have not been implemented as either they exceeded the scope of our research or we determined them to be low in terms of implementation priority.

Work Package No	*Responsibility*	*Type*	*Constraint*	*Solution*	*Start/Due Date*	*Completed*
99535-4-5	**McGrady**		**Install rebar along Broadway**		**6/29/00**	
	BBB					
		Contract	Resolve contract amount		6/14/00	☐
		Design	Resolve weight of rebar on PT deck		6/14/00	☐
		Design	Submit shop drawings to KFFP		6/14/00	☐
	Curtis Elevator					
		Prerequisite	99535-4-9 : Drill elevator shaft		6/16/00	☐
	Divisions					
		Prerequisite	99535-4-3 : Excavate footings		6/15/00	☐
	KFFP					
		Design	Approve shop drawings		6/21/00	☐
	McGrady					
		Design	Submit shop drawings to BBB		6/13/00	☐
		Material	Fabrication of rebar		6/27/00	☐
		Material	Delivery of rebar		6/28/00	☐

Figure 6: Constraints Report by Work Packages

Constraints Report

Responsibility	*Work Package No*	*Type*	*Constraint*	*Solution*	*Start/Due Date*	*Completed*
BBB						
99535-1-5	Install temp. fence					
		Prerequisite	99535-1-4 : Remove stripes from crosswalk		5/12/00	☐
		Prerequisite	99535-1-3 : Install closed sidewalk signs		5/12/00	☐
99535-4-5	Install rebar along Broadway					
		Contract	Resolve contract amount		6/14/00	☐
		Design	Resolve weight of rebar on PT deck		6/14/00	☐
		Design	Submit shop drawings to KFFP		6/14/00	☐

Figure 7: Constraints Report by Responsibility (for responsible party BBB)

REQUIREMENTS FOR LAST PLANNER TOOLS

Based on our experience in implementing and modifying WorkPlan, DePlan, and WorkMovePlan, we have identified several requirements for the Last Planner computer tools. These requirements are discussed next.

EFFECTIVE AND UNCOMPLICATED LAST PLANNER PROCEDURE

It goes without saying that a Last Planner computer tool needs to be based on comprehensive understanding and effective translation of the Last Planner methodology. This methodology is based on a very different view of construction planning than the

view taken by traditional construction project management. It may take some time for some project participants, whether they work for the owner, engineering design firm, general contractor, specialty contractors, or vendors/suppliers, to change their traditional view of the industry.

COORDINATION MEETING SUPPORT

Implementation of the Last Planner process relies heavily on the ability to collect information especially during the development of constraints, analysis of work package status, and formulation of reasons for failure. Information collection can occur either in a face-to-face meeting or in a distributed fashion. Regardless of how information is collected, coordination meetings will be helpful for project participants to get to know each other and establish a basis for communication, to identify and resolve conflicts, and to clear up vague items. In these meetings, the most up-to-date information needs to be available to the meeting participants in a format that they can easily recognize and interpret. Last Planner tools need to be designed to effectively support such coordination meetings.

EFFECTIVE INFORMATION DISTRIBUTION

Once all updates have been collected and processed, the latest information needs to be distributed either electronically or in hard-copy format. WorkMovePlan automatically synchronizes with other WorkMovePlans to ensure that every project participant has the latest information. WorkMovePlan also allows a planner to view the latest information on the web. This information is either pulled or pushed depending on the frequency of updates and their data formats. By contrast, in WorkPlan and DePlan, data needs to be sent either in electronic or in paper format. WorkPlan, DePlan, and WorkMovePlan already have many preformatted reports ready to be sent out or printed. What additional information needs to be distributed and in which form needs further study.

FAMILIAR USER INTERFACE AND DATA STRUCTURE

A familiar user interface and data structure will promote acceptance and avoid confusion when planners migrate from paper-based tools or other computer tools to Last Planner tools. As pointed out earlier, some project managers specifically asked that GUIs would look like Excel. Other project managers requested that reports would look exactly like the reports they have been using. Some but not all of these requests have been realized, depending on whether or not they met general needs. In terms of data structure, maintaining a level of detail for all information close to the level planners are used to seeing is very important, unless there is a strong reason to do otherwise.

INTERFACE WITH LEGACY SYSTEMS

WorkPlan, DePlan, and WorkMovePlan are planning tools that are specifically designed to support the lookahead and weekly work planning process. The responsibility for master scheduling is left to CPM-based scheduling tools. However, in order to fully maintain data integrity between the project schedule and the production schedules, WorkPlan, DePlan, or WorkMovePlan, and CPM-based master scheduling tools need to work together.

Additionally, many companies have their own accounting system and are not keen on changing it in any way. Therefore, Last Planner tools must be able to interact with these systems as well. Other interfaces might include interfaces to a personnel database, an equipment maintenance database, document control tools, etc.

OTHER REQUIREMENTS

The requirements listed above are either very important or they are requirements specific to Last Planner tools. However, other generic requirements exist. For instance, computer tools should:

- be reliable, e.g., the software should not crash or compute erroneous results
- allow for collection of information once and at the source, then allow for re-use anywhere it is required
- synchronize and update information to represent only the latest information
- be able to archive and recall past information

BARRIERS TO ADOPTION

The construction industry has consistently been accused of being slow to adopt technological change. However, once a technology has been proven to deliver and accepted, industry use spreads widely. Examples are today's common use in the United States of walkie-talkies, cellular phones, fax machines, Primavera Project Planner, and AutoCAD. Increasing numbers of PDAs are now seen at construction sites as well.

The use of Last Planner tools is closely related to the adoption of the Last Planner methodology. Currently, practitioners first adopt the Last Planner methodology, and then look for supporting computer tools. It remains to be seen whether the use of the tools, such as those presented here, can lead to the acceptance of lean construction principles with the Last Planner methodology in its broadest sense, encompassing front-end planning (Lean Construction Institute 1999, Ballard 2000) and lookahead planning (Ballard 1997, Tommelein and Ballard 1997) as well. Other researchers, including Chua, Jun, and Hwee (Chua et al. 1999, Jun et al. 2000), are also toying with computer implementations of the Last Planner methodology. We encourage others to do the same so that as a community we may speed up the practice of lean construction.

During an interview with a project manager and a superintendent of one of the largest contracting firms in California, it was clear that the notion of centralized control is still dominant in our industry. The superintendent said, "You always want to have more information than your subs, so that you have leverage over them." This mentality is both naive and short sighted. The lack of transparency of information creates adversarial relationships. He also said, "We have a very detailed master schedule [with activity durations no more than 4 to 5 days], so we can keep tight control over the subcontractors." When the project manager was asked to estimate their Percent Planned Complete (PPC, a concept in the Last Planner), he answered 35%. If that is indeed so, clearly, the superintendent's "tight control" is not very tight. However, tight control is rarely criticized as being the source of the problem whereas the lack of specialty contractors' abilities to execute as planned often is. Therefore, a "tighter control" is exercised.

A project engineer working on a construction project, which implemented the Last Planner methodology, expressed his frustration when trying to shift the subcontractors' thinking away from centralized control to distributed control. He said that some subcontractors came back and said, "Don't ask us what we can do, but just tell us what to do." Where these views of construction management are predominant, acceptance of Last Planner tools will not be easy. However, he also commented that "Now they understand and they have accepted it."

Transitioning from centralized control to distributed control is not easy. However, with the increasing specialization of specialty contractors and complexity of projects, and with the rapid advancements in information technology and communication infrastructure, the transition is well under way and it seems to be a matter of course.

CONCLUSIONS

The tools we have developed to implement the Last Planner methodology, namely WorkPlan, DePlan, and WorkMovePlan, have gone through several stages of modification from their inception until their current implementation, based on feedback from beta-testers. Between each stage, the requirements for Last Planner tools have become more clear. At the same time, the barriers to adoption have become better understood. These barriers are gradually being removed, with the spreading adoption of the Last Planner methodology, the increased acceptance of decentralized control, and the advancement of information technology. Further, deepened understanding of requirements and barriers will help in developing yet better specifications to enhance these tools.

It remains to be seen whether companies that are not on a lean journey can benefit from the Last Planner methodology as encapsulated in these computer programs, without first understanding and accepting the theory behind it. Many recent communication and computer tools do not require an explicit buy-in into any specific methodology. If the tools facilitate the adoption of the Last Planner methodology, the industry-wide practice of lean construction will grow even faster.

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