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Crew Level Planning

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Preamble

"Crew Level Planning" was first presented at the University of Texas Conference on Construction Productivity Improvement in 1981, and is republished here as a contribution to the pre-history of Lean Construction.

I was then Manager of Productivity Improvement for Brown & Root's Construction Division, responsible for forest products projects in the United States, having been appointed to this newly created position after working on the Chocolate Bayou Project, a joint venture petrochemical plant for Monsanto and Conoco south of Alvin, Texas. That project was the cover story in a 1980 issue of Engineering News Record (now "ENR") reporting success in productivity improvement and schedule recovery.

This is not an academic paper, but rather a contribution from an industry practitioner, many years away from becoming a professor. I joined Brown & Root as a pipefitter's helper in 1976 and moved from craft-worker to area engineer on the Chocolate Bayou project. As Manager of Productivity Improvement, I developed and supervised 'productivity analysts' on a number of Brown & Root projects in the United States. In 1980-81, productivity in our division improved by 10%. But I could see the need and potential for much more substantial improvement. My experience as craft-worker, construction engineer, and manager of productivity improvement is the basis for this paper.

The thinking in "Crew Level Planning" anticipates the Last Planner® System, which began to take its current shape in the early 1990s. The focus in this 1981 paper is on providing the conditions in which crew level planning is possible, at a time when most of the construction industry was trying to improve productivity through motivation and training. Contrary to those who assumed that the workers were the constraint, my experience identified management and the lack of 'structured craft planning'. Those of you familiar with Last Planner will recognize in this paper both shielding crews from bad assignments and the make ready process. Shielding is the foundation for productivity, quality and safety. Making work ready in the right sequence and rate is critical for project schedule performance. You will also see anticipations of collaborative planning and reliable promising.

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Hopefully this paper will be of interest to those who want to better understand where those ideas came from.

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Introduction

Planning at the crew level is conditioned by the planning done at higher organizational levels. Ideally, there is a project schedule that integrates design, procurement and construction; a master construction schedule; and discipline or systems schedules sufficiently detailed that the craft organizations can correlate them with their supervisory units. Using piping as an example, consider a craft organization divided by major process units, with geographic sub-divisions within those units assigned to general foremen. Scheduling information available to the craft varies with the nature of the job assignments over a range extending from responsibility for all piping in sub-area 2A through responsibility for completing sub-area 2A piping systems in a specific sequence, to a highly defined task of performing and completing specific activities at specific times.

Regardless of the type of schedule, the actual sequence of activities performed by the piping crews within sub-area 2A is determined by the flow of drawings and materials. "Primarily" because drawings and materials come first in the chain of decision making. Design decisions determine material requirements and materials are what work is done on. The job is complete when the proper materials are in place and related as per design. Manpower and equipment requirements are determined by the nature of the design-specific materials and the timing of their fabrication and positioning. Therefore, success or failure at upstream scheduling will be evident in the sequence and timing of material flow to the craft. Whether adequate or inadequate, material availability is the key determinant of crew level planning.

To the extent that specification of a fabrication sequence is a function of pre-determined erection sequence which craft supervisors help devise, craft planning also determines material flow. However, that is upstream of crew level planning and has already been absorbed and is now fully expressed in the sequence and timing of material flow. I assume that there is adequate upstream scheduling and that the sequence and timing of fabrication and material deliveries meets schedule requirements.

We will consider the problems of uniting those materials with the other elements of work in the actual construction process. It should be stressed that this assumption is highly artificial. In the real world, inadequacy of project and crew level planning compound one another and impede efforts at reform.

It is often lamented that foremen do not plan. Excessive craft delays are in part attributed to the failure of foremen to prearrange the junction of necessary elements. Craftsmen questionnaires, foreman delay surveys, and work sampling studies have each detected enormous amounts of time waiting for things to work with or for other crews to complete their work. Clearly the complaint is partially justified. However, consider the situation in which the foreman has to operate. Some studies show that pipe foremen spend

little more than half their time in direct supervision. And even that number is misleadingly inflated, for direct contact is typically not initiated by the foreman, but by craftsmen requesting assistance, information, decision, or intervention. The foreman spends a great deal of his time trying to get adequate information and figure out what he has available to work with. He inhabits a world to which he is usually reacting, and not acting upon. What kind of world is that?

We have assumed that the proper materials are available. We have not assumed that the foreman knows what is available, where it is located, or what the scheduled completion dates are. In order to understand and promote crew level planning, we must look at craft organization and procedures through which the crafts interface with support functions such as construction engineering, material control, receiving, warehousing, and then distributors of equipment, tools, and scaffolding.

Material control procedures are typically pre-established. Craft procedures for obtaining and distributing materials are not. They vary with individual superintendents and tend to vary at lower craft organizational levels. They also tend to change during the course of the project; either from the craft or site manager side and his concern to solve some specific problem, or from the side of the receiver or user, who continually devises new means to reduce waiting time and insure an adequate supply of material.

These variable interface procedures usually do not work. This is not a result of natural law, but of the failure to pre-plan and pre-establish procedures. Like many other project characteristics, procedures tend to evolve from casual and accidental decisions. The message is that crew level planning is destroyed by inadequate organization, which is a consequence of inadequate pre-planning at the management level.

But let's return to our piping foreman. He has a document that informs him of the availability of spools A, B, C and D on Drawing 112F. Drawing 112F is a part of the boiler feedwater system. His superintendent has been on him to complete that system. He orders the spools. He does not know when or if he will receive them. Suppose we spot check 38 such requisitions, none less than two weeks old, and 21 have disappeared into the void. Can we expect a foreman to plan in such circumstances? He does not know that the requisition reached the laydown yard, that the spools have really been fabricated and received, or that the moon is made of green cheese. He knows diddly-squat. It is apparent that we must develop and implement adequate interface procedures.

To promote recognition of that necessity, let's trace the impact of inadequate procedures for obtaining materials to their consequences in craft delays. Partly as a result of his concentration on materials, our imaginary foreman does not preview resource requirements or construction methods by drawing. He assigns the drawing to a pipefitter, who hopefully finds the spool pieces where they are supposed to be, and then accumulates the remaining materials such as gaskets, nipples, valves, instrument items, etc. Once he gets helper and welder lined out, the pipefitter takes a look at where the spool pieces are to go. He decides at that point in time that he needs a scaffold, a cherry picker, a 4100 Manitowoc, or whatever. Consequently, we find that craftsmen and craft supervisors consider lifting (and other) equipment and scaffolding just as they do tools. All should be immediately available on request. Because of the structure of task assignment, craftsmen have no choice but to expect them immediately. They are already working on the item for which the tool, scaffold, or crane is required. In addition, the struggle to obtain

information and materials has usually exhausted crew and foreman's fund of problem solving energy and time. Thus the attitude: 'Just give me something to work with and I'll build this blankitty-blank!'.

Inadequate lead time is not the only problem. If journeyman or foreman could depend on receiving each resource within a given time, they could more effectively allocate tasks. If they cannot predict when they will get a crane, welder, scaffold, or heli-arc rig, they must guess when assigning tasks. Craft handbooks are notorious for mandating the planning of 'alternative work', but they tell you nothing you need to know. Within limits, the lag time of a resource function such as equipment can be adequately dealt with. The killer is its unpredictability. The craftsman or foreman does not know how to assign his troops. Should they begin another job with its attendant string of uncertainties? Of course, bets are placed on the basis of past experience--but often the workers concerned are assigned to make-work tasks until the critical element appears; at which time, they are to drop everything and use the crane, scaffold, etc.

Resource Distribution Procedures

I am sure that many of you have been in shops where you had to 'take a number' in order to be served. We have traditionally handled resources in the same way. A first come-first serve order processing system appears to be a rational response to an unpredictable market. It is intended to defuse conflict over priorities and provide a systematic means for responding to requests. At least in our construction world, most resources are handled in that fashion. Consider tools, scaffolding, and equipment. Even materials are released upon request, not delivered to work areas in a pre-established sequence. There are several problems with that distribution system: 1) It does not adequately match up demand with supply. 2) It bottlenecks from 'breaking in line'., and 3) It discourages crew level planning. Even though a fully pre-planned release system might be logistically impossible, there are procedural changes to be made which can minimize the deficiencies of the common system. Consider hydraulic cranes: our investigations have revealed that the pivotal difference between allocation systems concerns the specification of the job for which the requisition is made. Consistent with the treatment of cranes like claw hammers, craft supervisors tend to want their own, and they often get them.

Control over equipment passes to the craft when neither description nor duration of the job is provided. This would seem to be favorable for craft planning because it reduces uncertainty concerning the availability of one of the elements of work. In practice, the opposite occurs. Craft assignment of hydraulic cranes increases rather than decreases craft delays. Consider this report by field analysts from a study of foreman activity. The foreman spent two hours searching for pipe spools supposedly already received. Once they were found, he went to get a crane to move them to the work site. The Pipe Department had been assigned two cranes for that building. The one assigned to the pipe foreman's side of the building was not there. He could not call for a crane from dispatch because it was understood that pipe personnel had their own cranes to use. Forty-five minutes later, the crane appears and moves the pipe. Equipment utilization studies indicate that craft assignment is accompanied by relatively low crane utilization. It promotes unproductive practices such as hiding the hook, excessive traveling, and poor methods of hook use. The means for changing the procedure from craft to job assignment are a requisition system

enforced by craft supervision and documentation which provides monitoring data. The obstacles to change are craft resistance to procedures and documentation.

The reason for that resistance is the belief that past procedures have not worked and that documentation is for someone else's purpose, and can only be harmful to the craft supervisor. Just as the failure to plan is only partially explained by the foreman's lack of planning skills, so the resistance to procedures and paperwork cannot be fully understood apart from the experience of the craft supervisors. Procedures have largely become obstacles to job performance. This is partly because of inefficient design of procedures, but also for two other reasons: the bosses do not follow the rules and they keep changing the rules.

It is commonplace for a craft superintendent to direct a general foreman to shift priorities; to 'get someone on the steam trace manifold!'. This happens all the time, and reflects both changes initiated at upper management levels and failure to incorporate previously states priorities in past construction practice. Regardless of cause, such changes 'screw things up'. Our foreman interviews often include mention of occasions when planned work was interrupted by changed priorities. Many foremen simply give up trying to plan.

A partial consequence of shifting priorities is breaking the rules. First come-first serve order processing is a common practice for on-site distribution of materials, tools, scaffolding, and equipment. 'Hot' items get priority; i.e., they justify breaking in line. This deteriorates morale, increases delays, destroys the effectiveness of the procedures for resource distribution, and insures an unbroken chain of 'hot' items.

The lack of crew level planning can be traced to inadequate procedures, ineffective organizational structures, imprecise job definitions, lack of performance measures, little or no vertical communications, and finally, untrained foremen. It would be foolish to ignore any of these contributing factors. I propose a solution intended to address all of them besides classroom training.

Structured Craft Planning

The intent of this proposal is to formalize the planning practices of good craft supervisors, thereby making them available to those less experienced or less innovative. There are three essential features of the proposed structure:

1. That it is "structured". Supervisor and subordinate meet at specific times, at set intervals, and perform assigned tasks, to be recorded on standard documents. This insures that planning occurs and that means are available to check that it occurs.
2. That supervisor and subordinate share responsibility for certain decisions. This insures feedback, promotes practicality of assignments and encourages commitment.
3. That the superior in each case is assigned responsibility for providing the resources necessary for the subordinate to execute the plan to which they have both agreed. This insures advance notice to resource suppliers, prevents the accumulation of tasks at the bottom of the organization, encourages the concept of the superior as supporter, and allows the schedule to be considered a work order, and thus something for which someone is accountable.

4. The intervals between meetings should vary with craft and construction phase. What is important is to have set meetings for planning within every set of circumstances. The participants in foreman/sub-crew meetings should also vary with the craft and type of tasks being performed. In piping, typically a single journeyman heads a sub-crew. In carpentry, the entire crew may be assigned to work on one foundation. What is important is to involve those who do the work in planning it. The type of planning to be done at each supervisor-subordinate node will generally become more detailed and less time-extensive as we approach the work force. The specific character of planning at each level will vary with the type of scheduling information provided to the craft. The following is a sketch illustrating the proposed structure:

Resources	Position	Interval	Planning Tasks
Information Manpower	Superintendent	Two Weeks	Determine priorities & required quantities by system
Materials	General Foreman	One Week	
Equipment	Foreman	Daily	
Small Tools	Craftworkers	Daily	

In each case, the planning session occurs prior to the execution phase. In the case of materials provision, there should be a sub-period (perhaps 3 days) to status material availability. The work sequence is then adjusted accordingly and becomes the foreman's work order, effective one week after the planning session. This allows him time to physically acquire the materials, consider task allocation, equipment requirements, and construction methods.

Craft-specific forms should be devised to record the agreements resulting from each meeting of supervisor and subordinate. They also serve as recording sheets for data; e.g., job duration and man-hour cost.

The advantages of this proposal are:

5. Explicit assignments. Everyone is accountable for performing scheduled work.
6. There is an incentive for identifying and removing obstacles to job performance.
7. There is a systematic way of communicating project requirements down the organization to impact the work itself.

8. Much better material control than under systems where anyone can pull material from storage areas.
9. More lead time for resource coordination.
10. Better defined position responsibilities. The foreman is no longer responsible for everything and thus capable of nothing.
11. Reduced interference from shifting priorities.
12. An explicit place in the construction process for considering and deciding upon work methods.
13. Stronger supervisory structure from the overlapping responsibility at each superior-subordinate "node".

Our present organizational structures are often called "chains of command", suggesting the prevailing view of the relationship between superior and subordinate. A "command" originates at the top of the triangle and gets transferred down each chain. Thus, at least one function of the organization is to translate orders from the boss to the work force, and then hopefully into action. That picture of their relationship is so vivid and clear that it obscures the reality and benefit of cooperation and joint decision-making between superior and subordinate. The pivotal distinction is between making decisions and carrying them out. The foreman and journeyman can agree on the daily workload and construction methods, but the journeyman is responsible for performing in accordance with that schedule. On the other hand, the journeyman cannot be held responsible if he does not get what he needs to work with.

In the structure proposed, there is joint responsibility for planning, with the supervisor assuming responsibility for providing whatever resource requirements are determined by the decisions made at that level. The principles on which this planning structure is designed are:

14. That everyone should have explicit assignments so that they know what is expected of them and what to expect of others.
15. That specific occasions be allocated for performing vital managerial and supervisory functions. (If we are serious about having our foremen plan, we should tell them exactly what to do and when to do it.)
16. That records be kept such that performance can be continuously monitored. Otherwise, there is no way to enforce the rules.

Together with structured craft planning, we are in the process of standardizing the procedures for resource allocation. This concerns materials, tools, scaffolding, and equipment. The principles in accordance with which individual procedures are formulated are as follows:

17. That a Delay Reduction Committee meet periodically to review resource requirements and distribution.
18. That the Committee consist of representatives of those who provide and those who use the resources.
19. That the Committee be the vehicle through which decisions are made concerning resource supply and distribution.
20. That means be provided for monitoring distribution/allocation systems from both supplier and user perspectives. Example: tool turndown logs and foreman delay surveys.

21. That all monitoring data be routinely provided to Committee members.
22. That rules and procedures be written, distributed, discussed, and enforced.
23. That the procedures include specific means for resolving conflict, ambiguity, and overriding priorities or sequence.
24. That every effort be made to minimize changes in procedures or priorities.

At least some of you are likely thinking that this planning structure is unrealistic, idealistic, and would only work under conditions like those we assumed at the beginning of this paper: adequate upstream scheduling and thus unproblematic information and material availability. It is apparent that poor project management can harm efforts at craft planning, but I contend that the structure here outlined is the only effective means of defense against it. Here is a final story about a young, bright aggressive Assistant Superintendent who attempted to implement a planning structure. Ken arrived on the job early. He had time to pre-determine fabrication sequence by construction sequence, to preview drawings for constructability, equipment requirements, etc. He must have thought he'd died and gone to heaven. Problems began when drawing delivery schedules started slipping, fabrication deliveries slipped, and when they arrived, were out of sequence, unconstructable partials, or already outdated by later revisions. Ken had assigned material responsibilities to his general foremen. As resource conditions deteriorated, the lead time required for specifying and accumulating sufficient materials for their respective foremen became longer and longer, until it became impossible. Ken finally had to assign expeditors to each of his foremen, with the instructions: "Steal it if you have to."

This story illustrates the harm suffered by attempts at craft planning in an unplanned and poorly managed context. Even so, of the Assistant Superintendents, only Ken was able consistently to account for materials and he had the best unit costs and most closely maintained schedule. If he had discontinued meetings, planning sessions, material control procedures—if he had given up the management practices he knew to be effective, he would not have been able to react when conditions allowed; i.e., when he finally received drawings and materials. He retained the structure that project conditions allowed him, and was able to do a very good job.

The contrast between how it is and how "it's s'posed to be", along with the proposed solution, is neither news nor new. Everyone realizes the importance of planning. It has become an 'apple pie item'; i.e., one no one dares dispute. Real and effective response to the situation described is, however, more often claimed than carried out. The obstacles to effective response are as complex as are the forces impacting on construction productivity, but some significant barriers can be specified.

The old distinction between planners and doers has not been overcome. It is rare that it has even been confronted. Field managers and superintendents often do not understand the principles of planning and scheduling. Consequently, their acceptance of planning programs is more apparent than real; they do not know what to do with them.

Appetite has its role to play alongside understanding (or its lack). Many field supervisors find it comfortable to be able to displace blame onto some other part of the construction effort; preferably one as far away as possible

from his own scene of responsibility. The individual characteristics of field supervisors is supplemented by the lack of organizational means for overcoming the isolation of positions and functions. Group A can plausibly displace blame onto Group B when there is no clear relationship between the two. In such circumstances, it is difficult to determine the facts.

This lack of organizational precision is not least apparent in the planning structure itself. I do not consider project and crew level planning to be in opposition to one another. They are equally necessary to the successful performance of contractual obligations. In fact, the structure or craft planning presented here is a necessary extension of the concept of project management to the action level of the organization. The implementation of structured craft planning and practical supervisor training would go a long way toward achieving the kind of control we need to manage our projects.

Project Control

We have typically tried to maintain project control by reliance on measures of output, the result of work-activity revealed in the work-product. When those results fall short of schedule or cost requirements, management relies on line supervisors to find the cause of the problem and correct it. The supervisor does not always have adequate additional information with which to do either. Output measures such as unit costs are the result of complex forces, of which only one is the management skill of individual craft supervisors.

Consequently, effective control requires the development and implementation of performance measures and procedures more directly focused on the specific operations contributing to cost or schedule performance. As a part of project control, planning and scheduling must be taken down to the action level. Craft operations are black holes without definition. We do not teach supervisors how to plan, we do not provide them adequate support for planning, we do not encourage or reward planning, and we do not demand planning. Similarly, the hullabaloo about materials management somehow mysteriously crescendos prior to the point of application. Consequently, craft supervisors consider schedules and material control procedures to be obstacles to their own job performance and they are right.

This is not simply a function of undereducated construction managers and craft supervisors. It is also a reflection of our failure to structure production for proper management. This would involve the application of industrial engineering techniques developed in other industry areas, as well as means for the development of techniques and structures peculiar to the construction industry.

An illustration can be drawn from the problem of timeliness in the area of material status reports. Field and material management usually are in conflict over the accuracy of reported dates and locations, in part because input time and report issue intervals combine to render data out-of-date. The problem appears to be dealt with only by negotiation of demands and resistance. What a real manager would do is consider the operation which requires the data

demanded. We should increase the time-scope for planning construction operations. To do so requires, but requires more than, a good project schedule. It requires a structured construction operation which applies schedules.