Contractor Prebid Planning Principles

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Abstract: Planning is an essential function of project management. Yet, many small- and medium-sized contractors do a relatively poor job of operational planning. Better prebid plans will reduce costs, shorten schedules, and improve labor productivity. Unfortunately, the published literature offers little guidance for smaller contractors on what constitutes effective planning. Most papers describe planning as a macrolevel process for owners. Most emphasize scope definition for industrial projects. This paper describes a microlevel planning process for contractors. It consists of eight steps which are: (1) assess contract risks; (2) develop a preliminary execution plan; (3) develop site layout plans; (4) identify the sequences that are essential-to-success; (5) develop detailed operational plans; (6) develop proactive strategies to assure construction input into design; (7) revise the preliminary plan; and (8) communicate and enforce the plan. The entire process is illustrated with a case study project and is fully illustrated with figures which show how to integrate the work of multiple contractors, keep key resources (crews or equipment) fully engaged with no downtime, provide time buffers so the work of follow on crews can be efficiently done, expedite the schedule using multiple work stations and concurrent work, ways to communicate the work plan to the superintendent and foremen, and how to assess the feasibility of various work methods. The steps are easy to understand and implement. They will yield immediate positive results.

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CE Database subject headings: Construction costs; Productivity; Labor; Scheduling; Contractors; Planning.

Objective

The objective of this paper is to begin to define the short-range (as opposed to strategic) steps that define an effective contractor project planning process during the prebid phase for small- and medium-size projects. These steps will lead to better productivity, lower cost, and shorter schedules.

The process outlined in this paper is useful in training undergraduate civil engineers and contractors as well.

Methodology

The steps in planning are based on more than 30 years of observing site construction operations. During observations, labor productivity was measured and disruptions were noted. The two parameters were correlated. A number of problems or disruptions related to planning were observed, and these disruptions almost always led to significant degradations in labor productivity. Using deductive reasoning it is concluded that degradations in productivity results whenever planning related disruptions occur. Therefore, these disruptions must be avoided at all costs. The principles cited herein were developed to avoid these disruptions. They are but an initial start and other steps can added as the situation dictates. The steps have been intentionally left general so as to be readily understood and applicable to a wide range of circumstances. The principles were shared with several local contractors to validate their suitability.

Over the last 30 years, the authors have observed and monitored productivity and performance on over 200 projects amounting to approximately $1.5 billion. The types of projects monitored include apartment buildings, condominiums, commercial offices, parking garages (above and below ground), government buildings, wastewater plants, highways, bridges, research/classroom buildings, and residential sites. Activities studied in detail include masonry, concrete formwork, steel reinforcement, concrete placement, structural steel erection, caisson drilling, partition wall framing and drywall, duct installation, underground conduit, excavation, asphalt paving, and concrete paving. Additionally, the authors have published approximately 130 technical papers on labor productivity issues. Dr. Thomas has been a professor of civil engineering for more than 30 years. Dr. Ellis was president of an international construction company for 15 years. With these experiences the writers feel qualified to make the recommendations contained in this paper.

Literature Review

Considering the importance of planning, the literature is surprisingly void of articles on effective construction planning. Most of the ASCE literature on planning seems to relate to environmental, transportation, the owner planning process, scope definition, and water resources planning. There is little related to construction project planning that would be of use to contractors. The literature topics related to planning that are reviewed in this paper are under

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the topical headings of: general, processes and models, site layout, and constructability.

General

As defined by the Construction Management Association of America (CMAA), "construction management is a professional service that applies to effective management techniques to the planning, design, and construction of a project…(CMAA)."

There are numerous texts and articles on the critical path method (CPM) of scheduling that describe planning as a process of defining the activities in a CPM schedule and determining the order of precedence of these activities. Planning as seen by CMAA is much more than this. The planning as it relates to a CPM schedule is much too narrow to define effective planning.

Laufer et al. (1993) described the planning process as the integration of a set of interdependent decisions that results in a plan. He described the plan as one that answers the questions: (1) what is the involvement of the participating parties in planning?; (2) what is the effort invested in planning?; (3) how many types of plans are issued?; and (4) what formats are used for plans?

Processes and Models

Gibson defined project preplanning as the process of developing sufficient strategic information for owners to address risks and to decide whether to proceed with a capital project (Gibson et al. 1995). He pointed out that many construction industry experts believe that early planning efforts have much influence on project success. Using a Level 1 IDEF( ) model, Gibson defined the steps in the owner preproject planning process as: (1) organize for preproject planning; (2) select alternatives; (3) develop project definition packages; and (4) make decisions. The major subprocesses of the owner preproject planning process were defined in more detail using Level 2 IDEF( ) models. Gibson's model made no assessment as to whether the model was complete or if it contributed positively to better cost and schedule performance; it merely reported what owners do. The model was too general to be used as a framework for contractor planning. The model was a strategic model for use by industrial owners.

In a subsequent paper by Gibson et al. (2006), he wrote of five major studies investigating project preplanning. The studies covered more than 200 capital projects (from 1994 to 2001) representing about $8.7 billion. Survey instruments and interviews were used to show that effective preplanning lead to improved performance in terms of cost, schedule, and operational characteristics. The paper described a project definition rating index which is a weighted matrix describing 70 scope definition elements. He concluded that: (1) preproject planning is a process that can positively impact capital project performance; (2) preproject planning is a critical project process that must be performed consistently on each project; (3) the project manager and team must ensure that it is performing the "right project;" (4) the project manager and team must ensure that it is developing the "right work product" during preproject planning; and (5) the project manager and team must choose the "right approach" to project design and construction execution.

In a 1997 article by Faniran, the authors presented several strategies for improving planning practices (Faniran et al. 1998). Data and information were gathered via a questionnaire. Because a questionnaire was used, the paper reports current practice, not necessarily best practice. The authors concluded that planning would be more effective if there were: (1) more investment of quality time in preconstruction planning; (2) less emphasis on developing schedules; and (3) more emphasis on developing operational plans. The authors made extensive use of statistical correlations and regression modeling as the basis of their conclusions, but it is hard to envision how the authors could support their conclusions since most correlation coefficients were below 0.50 and the best r_a^2 value was 0.60.

Site Layout

All authors recognize the complexity of the site layout problem. All generally agree that there are multiple selection criteria, multiple constraints, and the plan changes over time. The site plan used at the beginning of the project may not be suitable for the middle or latter part of the project.

Mawdesley et al. provides a good discussion of the factors to consider during site layout and planning (2002). The factors include the location of access and traffic routes, material storage and handling areas, administration buildings and welfare facilities, and equipment workshops and services.

Constructability

There is little argument that design plays an important role in project performance. Most published papers related to design impacts champion constructability reviews as a way to minimize design errors, identify more workable design solutions, produce construction-friendly specifications, etc.

An authorative report on constructability reviews was written by Anderson and published by the National Cooperative Highway Research Program (NCHRP) in 1997 (Anderson and Fisher 1997). Anderson observed that constructability reviews were often driven by project milestones and were conducted late in the design process as part of the final design review. Minimal reviews were done in the planning phase. In a 2001 NCHRP report by Thomas and Ellis, it was also identified that the review may occur as per a predetermined date, even if key documents needed for the review are not available (Thomas et al. 2001). The Anderson report contains a good bibliography and the subject of constructability will not be reviewed further in this paper. Sadly, on most private, low-bid projects, there is little opportunity for contractor input into the design phase.

Case Study Description

The steps in the proposed prebid planning process are best illustrated with a case study project. The proposed guidelines were applied retrospectively to this project. The case study project is the three-story State College Municipal Building (SCMB). It was constructed in State College, Penn. in 2002 at a cost of about $10 million United States.

The building superstructure was structural steel. The slabs were precast concrete. The project also contains a full-footprint basement. Construction of the basement required excavation, rock removal, footers, and construction of a reinforced concrete wall. The building façade was masonry. Fig. 1 shows the status of the SCMB construction after the precast slabs were installed.

The site was small. It was constrained on all four sides by city streets and existing buildings. Ingress and egress points were limited. The building footprint took about 60–70% of the site so space for material storage, etc., was minimal. The constrained nature of the site is shown in Fig. 2, which shows the site layout

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Fig. 1. SCMB during construction

used by the contractor throughout the project. Using this layout, delivery trucks had difficulty in accessing the site and the spoil pile occupied valuable storage space.

The construction of this project was challenging, even though it was a small project. Careful planning was justified.

Steps in Project Planning

The proposed process described below should be viewed as a starting point and more steps can be added as the need arises. However, the process should remain general so as to be applicable to numerous projects. The eight steps in the proposed planning process are: (1) assess contract risks; (2) develop a preliminary execution plan; (3) develop site layout plans; (4) identify the sequences that are essential to success (ETS); (5) develop detailed operational plans; (6) develop proactive strategies to assure construction input into design; (7) revise the preliminary plan; and (8) communicate and enforce the plan. Since the process should be flexible and each step should provide input to the next step, it is permissible to revise a previous step if a better plan emerges.

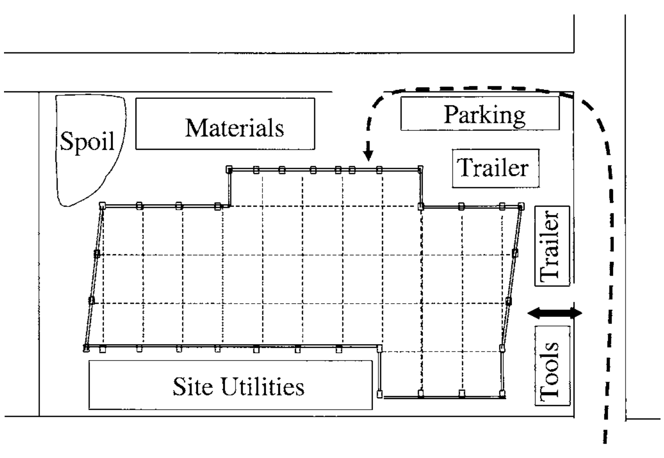

Fig. 2. Site layout for SCMB

Table 1. Fundamental Principles of Developing Preliminary Execution Plan

1.1	Plans and schedules should be done at a macro level
1.2	Make effective use of constructed and footprint areas
1.3	To allow more room and to mitigate rain runoff, install utilities and permanent site drainage first
1.4	Minimize storage area needs by off loading directly from the delivery truck
1.5	Minimize storage area needs, enhance the schedule, and improve labor performance by preloading materials onto each floor or area
1.6	Make use of service elevators to transport lightweight or bulky items like duct and drywall to each floor or area
1.7	Sequence activities so as to avoid making noncritical activities critical
1.8	Execute activities concurrently, rather than sequentially

Assess Contract Risks

Planning begins with an assessment of the contract risks. Many contracts are known to contain harsh language that imposes significant risks on contractors and subcontractors. These risks need to be known before the bid is submitted (Thomas et al. 2000). Additionally, contracts may contain language related to methods and when certain operations can be performed. A careful reading of the contract is paramount.

Develop Preliminary Execution Plan

A preliminary execution plan should be developed at the outset. This plan should be developed at the macrolevel and should assume the character of a milestone bar chart or a milestone (Level 0) CPM. This schedule is used to determine if the methods and sequences chosen will allow the contractor to complete the project on time. Fortunately, there are a limited number of ways to build a project and to develop a macroexecution plan. Table 1 presents some fundamental principles for developing a preliminary execution plan. As more detail is developed in subsequent steps, the preliminary plan/schedule should be revised.

Fig. 3 shows a 36-week preliminary execution schedule based in part on how the contractor executed the project. Fig. 4 shows the same schedule when activities are executed concurrently rather than sequentially (Table 1, Principle 1.8). There has been about a 25% reduction in the scheduled weeks, even though the activity durations are the same.

The main differences between Figs. 3 and 4 are: the excavation can begin as mobilization begins or shortly thereafter, excavation–rock removal–basement walls are done concurrently structural steel–precast floor planks–preloading (not shown) are integrated, underground utilities must be completed before structural steel can begin, and the order of ground slabs–masonry partition walls–ground floor precast slabs has been changed.

No activities were added or deleted, nor were any activity durations changed. Yet, there has been about a 25% reduction (8 weeks) in the scheduled (to 28) weeks simply by applying Principles 1.11 and 1.12.

In comparing Figs. 3 and 4, it is observed that ground slabs (in the basement) and the first floor precast slabs must be done before the masonry partition walls (in the basement) are done. If the ground slabs are done first, then both slab activities are critical path activities. But if the precast slabs for the first floor are done first, then the ground slabs can be done concurrently with other

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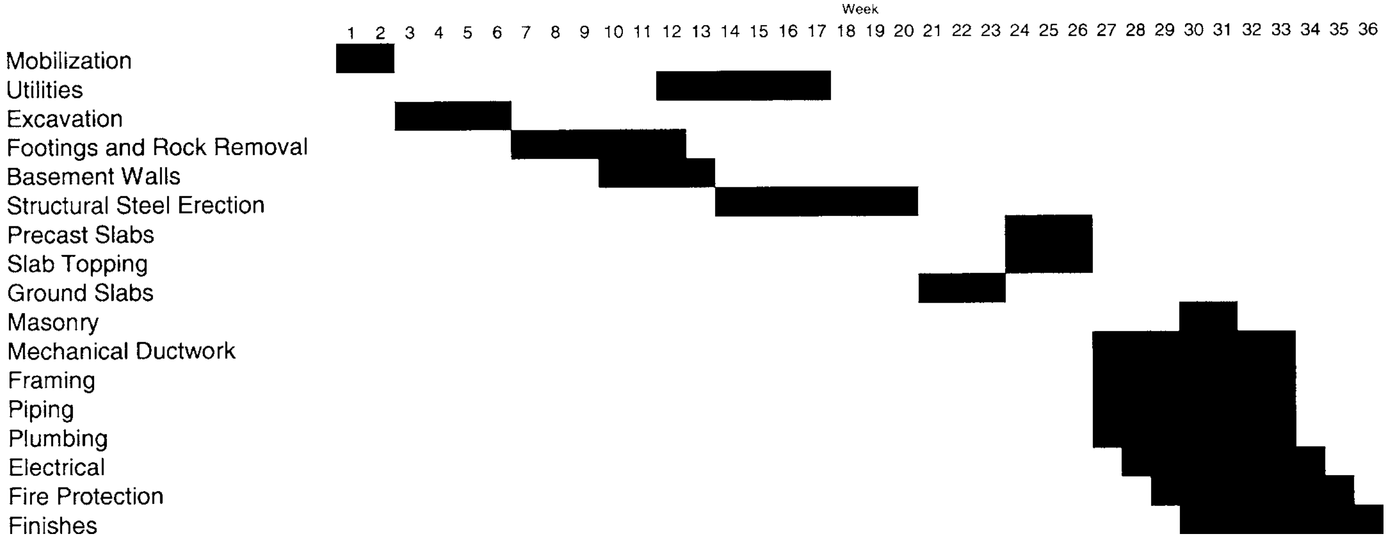

Fig. 3. Preliminary execution plan

activities at a later time, thus making the ground slabs not on the critical path (Table 1, Principle 1.11). This situation is often true of ground slabs.

In comparing the two figures, it is seen that ground slabs (in the basement) and the first floor precast slabs must be done before the masonry partition walls (in the basement) can be done. If the ground slab is done first, then both slab activities are on the critical path (see Fig. 3). But if the precast slabs are done first (see Fig. 4), then the ground slabs can be done concurrently with other activities at a later time, thus making the ground slabs noncritical (Table 1, Principle 1.7). The application of Principle 1.7 also results in a shorter schedule.

Develop Site Layout Plans

Generally speaking, many contractors do a poor job of detailed site planning. In monitoring more than 200 projects over the past 30 years, the writers have yet to observe a project where there were comprehensive site plans. Additionally, research has offered little insight into the mechanics of developing a site plan.

Multiple site plans are needed because the site needs change. Normally, three plans are needed, but for larger, more complex projects more plans may be justified. A new plan is needed whenever material deliveries requirements change significantly, space/access requirements change, or new resources are deleted or added. For the SCMB, three plans are proposed for the three main phases of the project: foundation, superstructure, and services/finishes.

The steps in developing a site plan are given in Table 2. Fig. 5 shows the proposed retrospective site plan for the structural phase only of the SCMB. (Fig. 2 shows the actual site layout used throughout the project.) With the proposed plan, drive-through deliveries are possible, and there is more on-site storage space if needed. Parking has been moved off site, and the spoil pile is removed. The site utilities are to be completed prior to the com-

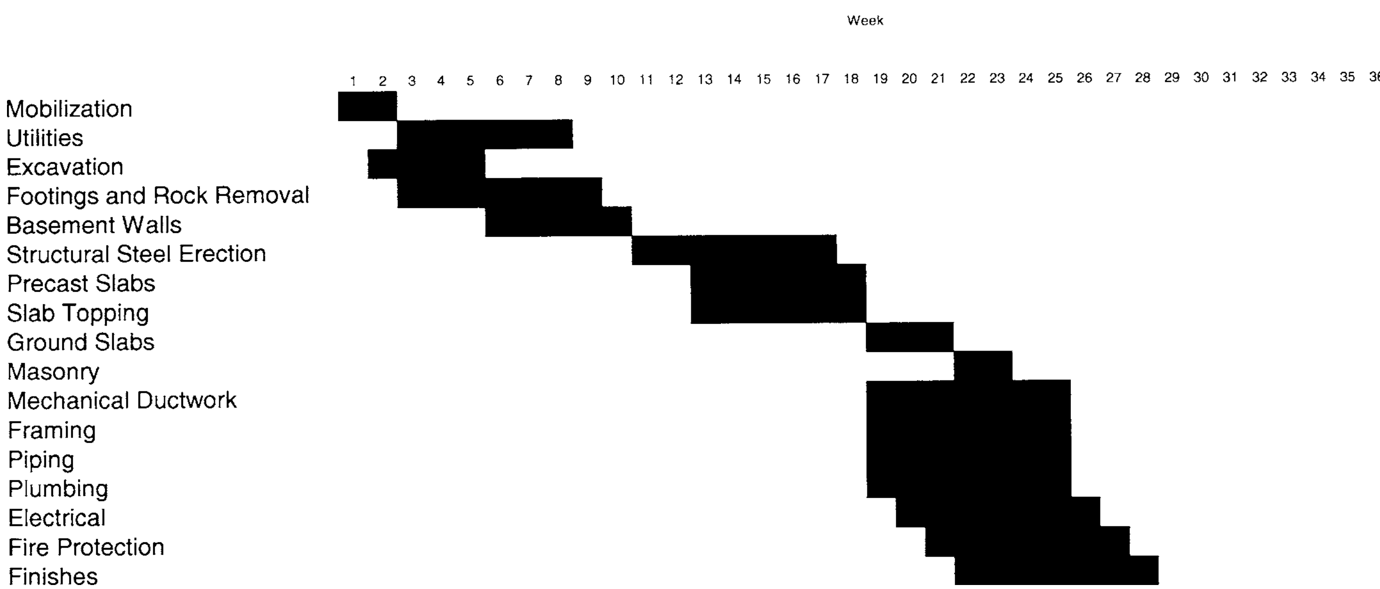

Fig. 4. Revised preliminary execution plan

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Table 2. Steps in Development of Site Plans

Step number	Description
1.	Develop an accurate drawing of the site and surrounding area
2.	Locate concrete discharge and crane pick locations
3.	Locate ingress and egress points for material deliveries and pedestrians
4.	Map the traffic routes for vehicles and pedestrians. Whenever possible, these should not cross. Avoid traffic routes that require the backing of delivery trucks. Drive-through deliveries are preferred.
5.	Select material storage locations
6.	Identify necessary temporary facilities, work spaces, etc. and locate trailers, tool sheds, parking areas, etc.
7.	Evaluate and refine layout plans
8.	Repeat steps 2 through 7 for each phase (unique site plan)
9.	Communicate and enforce plans

mencement of steel erection. The lifting radius of one crane is shown. There can be multiple plans, and Fig. 5 is but one solution the site layout problem.

Identify ETS Sequences

One does not have the resources or time to plan in intricate detail all the aspects of constructing a project. Fortunately, on essentially all projects it is possible to identify one or more aspects of the project that are ETS." In this step ETS sequences, which may be a single activity or a string of activities, are identified, and the limited resources are marshaled to plan these sequences in detail.

ETS sequences differ from critical path activities in a CPM schedule. While critical path activities cover the entire project, ETS sequences may be only one activity or a limited number of loosely connected activities. An ETS sequence need not be a critical activity in the CPM vernacular. The ETS sequences are unique to each project. The common denominator is that the activity(s) must be done in an orderly or timely manner if the project is to be successfully completed.

Several ETS sequences are attractive on most projects. For example, it is always desirable to complete the foundation work quickly to minimize the exposure to rain and mud. In colder climates it is often desirable to complete the roof and enclose the building before winter. In rainy climates, it is desirable to seal the building. There can be several ETS sequences on a single project.

On the SCMB project, two ETS sequences were identified. These were:

1. FOUNDATION: Excavation–rock removal–footings–concrete wall; and
2. SUPERSTRUCTURE: Structural steel erection–precast plank installation–preloading service/finish contractor's materials.

The concrete foundation wall was selected because it must be completed before the steel erection can begin, and because of the desire to limit weather risks. The rapid removal of rock is essential and the selection of a method is of paramount importance. In many CPM schedules, rock removal and footings would not be critical activities. The steel–plank–preloading activities were also selected as an ETS sequence because their work must be integrated. If steel is erected first, then inefficient work methods will be needed to install the planks and to deliver the service/finish materials to each floor. These three activities may not be linked in a CPM schedule, yet how this work is integrated will have much to do with how productive and timely the service/finish work will be done. It is noted that the both ETS sequences cited above all are concurrent activities.

Develop Detailed Operational Plans

Detailed operational plans need to be consistent with the preliminary execution plan. If the execution plan calls for 20 days to construct a foundation, then the operational plan should also say 20 days or less. If a change needs to be made, the execution plan

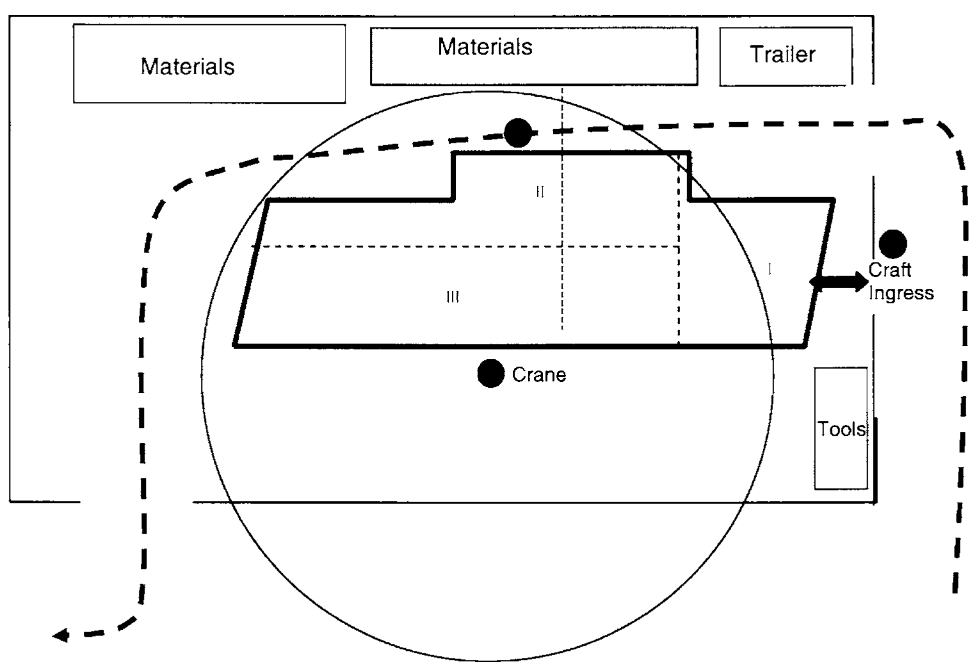

Fig. 5. Proposed site layout for structural phase, SCMB

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Table 3. Fundamental Principles of Developing Operational Plans

Number	Principle
1.1	Partition site into work area or zones
1.2	Use multiple work stations to accelerate the work
1.3	Perform work concurrently rather than sequentially
1.4	Schedule the work to accommodate continuity of work of key resources
1.5	Establish appropriate crew sizes and teams
1.6	Integrate the work of multiple contractors
1.7	Apply time lags or buffers

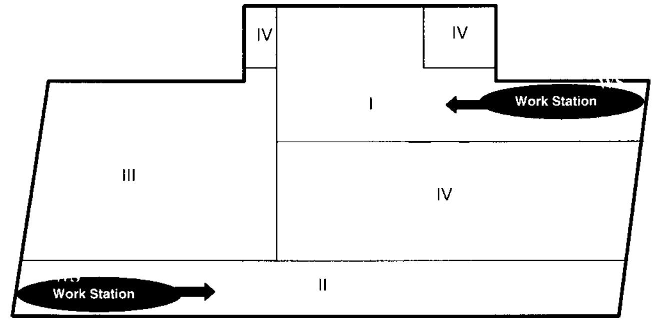

Fig. 6. Operational plan showing partitioning into work areas

rather than the operational plan should be the plan most likely to be modified. Principles for developing operational plans are given in Table 3. As a minimum, plans should be developed for all ETS sequences.

The goals of developing detailed operational plans can be many and varied. Some of the more common goals are to: (1) accelerate the schedule; (2) assure an efficient work plan and methods; (3) determine resource needs, assure continuity of work for key resources; (4) determine time lags; (5) integrate the work of multiple contractors; and (6) assure safety and quality.

There are multiple tools that can be used to develop operational plans. Some of the more common tools are given in Table 4. The most common tools are the: (1) bar charts; (2) short interval production schedules (SIPS); (3) velocity charts; and (4) linear schedules. These tools are illustrated in Table 3.

Partition Site into Work Areas

It is often useful to partition the site into work zones or areas. This task may need revision as the details of the operational plans are developed. Multiple work areas facilitate multiple work stations and concurrent work.

Fig. 6 shows the excavation on the SCMB is to be partitioned into four areas. The partitioning applies mainly to the excavation. Area I is excavated first thus making it possible to begin rock removal at one workstation. Area II is excavated next allowing rock removal to begin at the other workstation.

Fig. 6 should be viewed as a preliminary plan that may be revised later. The value of this plan is that it allows for expedited rock removal.

Short Interval Production Schedules

The SIPS is a detailed schedule that shows what work will be performed and when. It covers a short period of time (say 1–3 weeks) and generally is applied to cyclical work. It is not a look-ahead schedule because there is no element of hope in the SIPS. Once developed, it becomes a commitment that binds all parties. The need to integrate work areas and resources with time should be obvious. A SIPS should be developed for all ETS sequences and subcontractors need to be intricately involved.

Example 1 An example SIPS for an apartment building (not SCMB) is given in Fig. 7. On this project it was determined that the ETS sequence was the completion of the roof by the end of November, and to achieve this goal, it was necessary to complete one floor of the superstructure per week. The superstructure consisted of reinforced masonry walls (both interior and exterior) and precast floor planks. Thus, the ETS was SUPERSTRUCTURE: interior and exterior reinforced masonry walls–wall grout–installation of precast floor planks–plank grout–curing–preloading masonry units. The SIPS showed that for this plan to be feasible, the resources needed were: about 35 masons and helpers working at seven work stations, a mortar and grout mix that will cure to the required strength in about 18 h during colder weather, and regimented deliveries of block, mortar, and grout.

On the basis of the SIPS, it was decided that this goal was feasible although tight. Notice that the SIPS makes it possible to assess feasibility and the requirements for the plan to be doable. A word of caution is warranted. If the time for this work is made too liberal, it can cost the contractor money; some flexibility to modify the schedule is needed. For instance, suppose one task is scheduled for 3 days, but it can be completed in 21/2 days. Unless the schedule is adjusted, the crafts may stretch the work on that task to the full 3 days or spend the last 1/2 day in preparation for the next day or in cleanup. It is a mistake to schedule certain work to occur at a certain time (each week) without the benefit of experience to assure the time allotted is suitable.

Example 2. This example is for the SCMB and the ETS sequence is related to the structural steel erection–precast plank installation–preloading service/finish contractor's materials sequence. Efficient and timely completion of this work is essential to success of the project because if the steel is completely erected, then the precast planks and preloading cannot be done using a crane.

Fig. 8 shows a SIPS for the steel erection–plank installation–preloading to be done using three cranes. The work area is partitioned into three work zones, and a single crane is assigned to each zone (see Fig. 5). Service and finish contractors need to arrange for the early and timely delivery of their materials. If they are late, their materials will not get preloaded. Steel and plank deliveries must also be on a strict schedule. Duct will be stored in the basement (Table 1, Principle 1.2).

Velocity Charts

A velocity chart shows the daily production rate of one or more concurrent activities. Fig. 9 shows a hypothetical example for the

Table 4. Tools Used in Developing Operational Plans

Guidelines	Tool	Outcome
Partition site into work area	Bar chart	Accelerated the schedule
Multiple work stations	SIPS	Accelerated the schedule
Concurrent work	SIPS	Accelerated the schedule
Crew sizes and teams	Linear scheduling	Efficient work methods
Multiple contractor work Integration	SIPS	Efficient work methods
Buffers	Velocity charts	Efficient work methods

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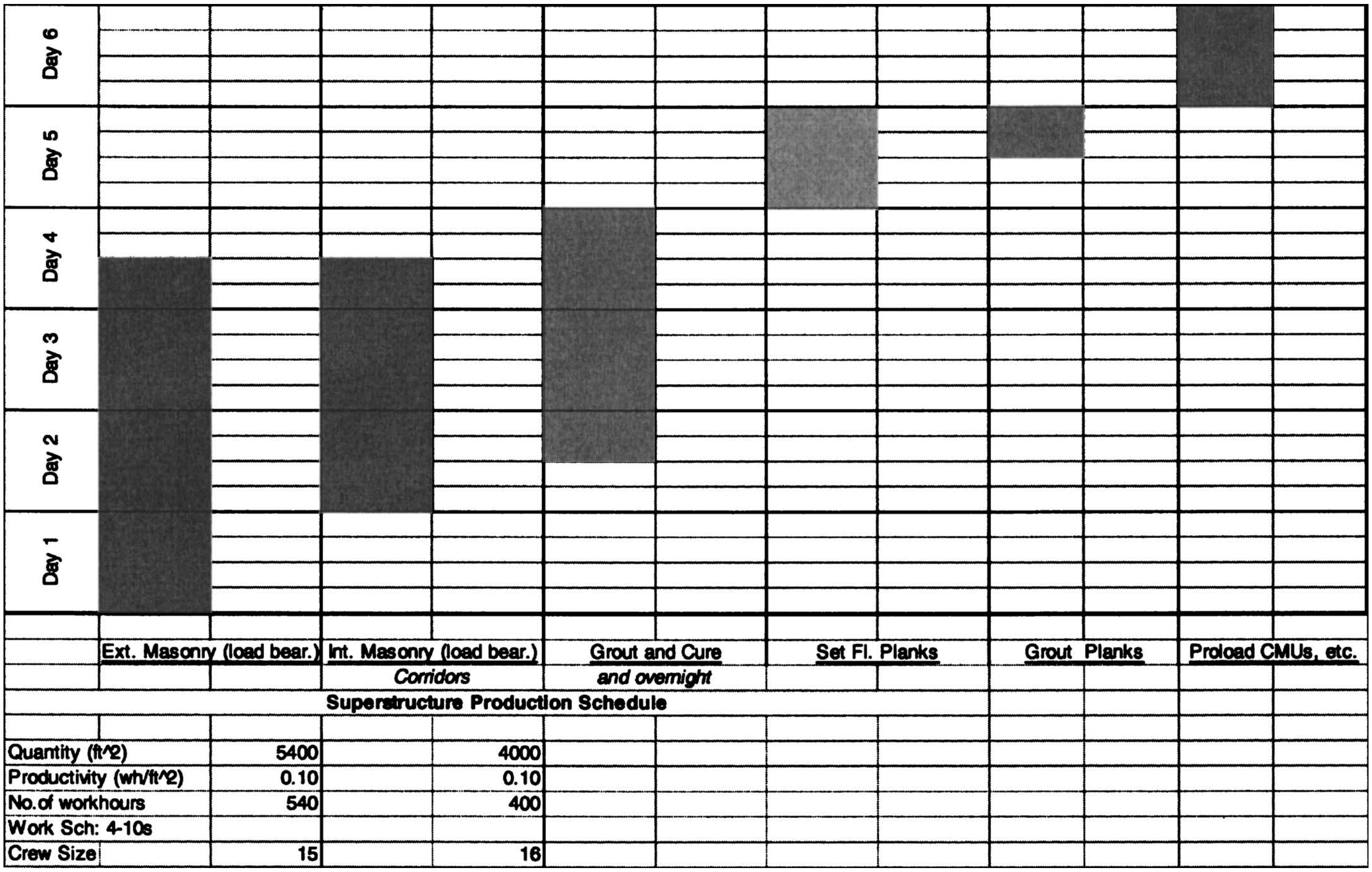

Fig. 7. SIPS for superstructure ETS, Bryce Jordan Tower

excavation–rock removal–footings–concrete wall ETS sequence on the SCMB. The velocity chart is particularly useful when the production rate of one activity is much slower than the others, in the case of SCMB—the rock removal. In this instance, the velocity chart can be used to estimate the lag time or buffer for the footings. Without time lags or buffers, all the ensuing work will be highly inefficient. In this instance, the velocity chart can be used to evaluate various alternatives for accelerating the schedule, such as multiple work stations and multiple crews for rock removal or faster methods.

Day	I.	II.	III.
11			Preload
10	Distribute Materials		Planks, Set and Grout
9	Preload Materials		
8		Planks, Set and Grout	Structural Steel Erection
7			
6		Align	
5	Planks, Set and Grout	Structural Steel Erection	
4			
3	Align		
2	Structural Steel Erection		
1			

Fig. 8. SIPS for superstructure ETS, SCMB

Linear Schedules

Linear schedules show the relationship between time and location. These graphical schedules are usually associated with linear projects, i.e., highways, pipelines, etc., but they also have limited application on nonlinear projects in assuring continuity of work of key resources, such as a concrete crew or crane. Harmelink and Rowings showed how to identify controlling activities with linear schedules (Harmelink and Rowings 1998). Ideally, to avoid inefficient downtime, a crew should proceed from one activity to the

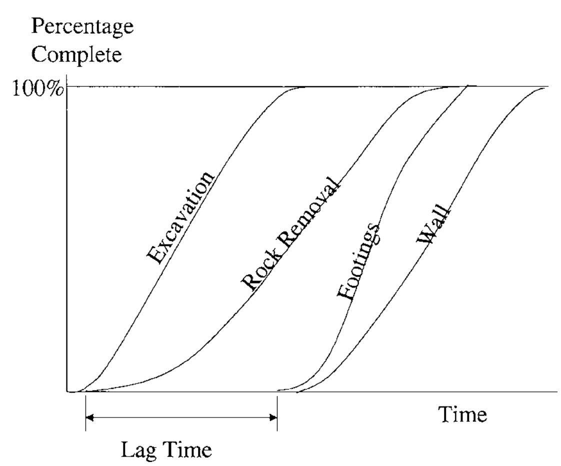

Fig. 9. Hypothetical velocity chart for foundation/basement ETS, SCMB

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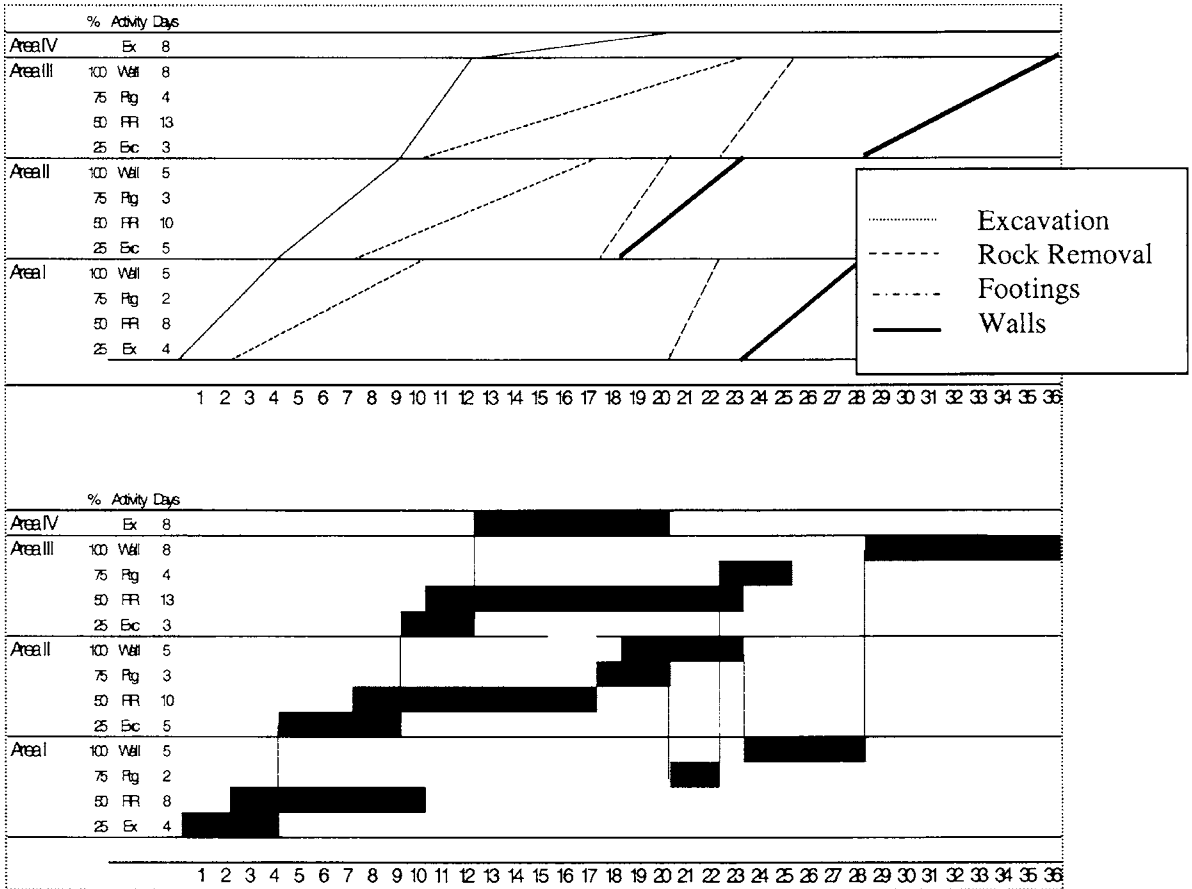

Fig. 10. Linear schedule and bar chart for foundation ETS, SCMB

next without delay. Linear schedules allow one to visualize how efficiently a resource is being used and to maintain continuity on noncritical activities.

To illustrate the linear schedule, the FOUNDATION ETS on the SCMB is used. Fig. 6 showed the excavation work area was partitioned into four work areas. Note that if the site is not partitioned, the development of a linear schedule will be very challenging. Fig. 10 shows the linear schedule and a bar chart. Following some minor adjustments, it is possible to have continuity of work for the excavation and for the footing and wall formwork crews. So only one crew for each of these activities is required. The same cannot be said for the rock removal crew. A single rock removal crew would extend the schedule, and so two crews are planned. The crew sizes will be adjusted to assure the daily production goals are met. Time lags are also visible in Fig. 10. For example, the time lag in Area 1 between the completion of rock removal and the start of the footings is 10 days.

Proactive Strategies to Assure Construction Input into Design

The opportunity to provide construction input into design may be limited on projects that are competitively bid in the design–bid–build tradition. However, there are two alternatives that offer some opportunities to do so: value engineering and alternative bidding.

Greater opportunities for construction input into the design are possible with delivery methods that engage the contractor early in the design phase. Two of the most common methods are: design–build and construction manager.

Value Engineering

Where the contract allows VE, the contractor may prepare an alternative design or proposal for the owner's consideration after the contract is signed. If accepted, the owner and contractor share in the cost savings.

The problem for the contractor with VE is twofold. First, there may be insufficient time for the contractor to investigate and/or design an alternative. Also, the owner may take an inordinate amount of time to review the proposal. Complex proposals that provide significant project benefits can be very time consuming to review.

The second problem for the contractor with VE is the contactor's reluctance to pursue a complex VE proposal. If the proposal is rejected, the investigative and design expenses come off the contractor's bottom line (profit), and the contractor must absorb the cost.

Alternative Bidding

Another option is to include alternatives to the base bid. Bid proposals must always contain a base bid cost for exactly what the contract documents require, otherwise the contractor's bid is not responsive to the solicitation and the bid may be rejected. However, the contractor should be able to say to the owner: if you

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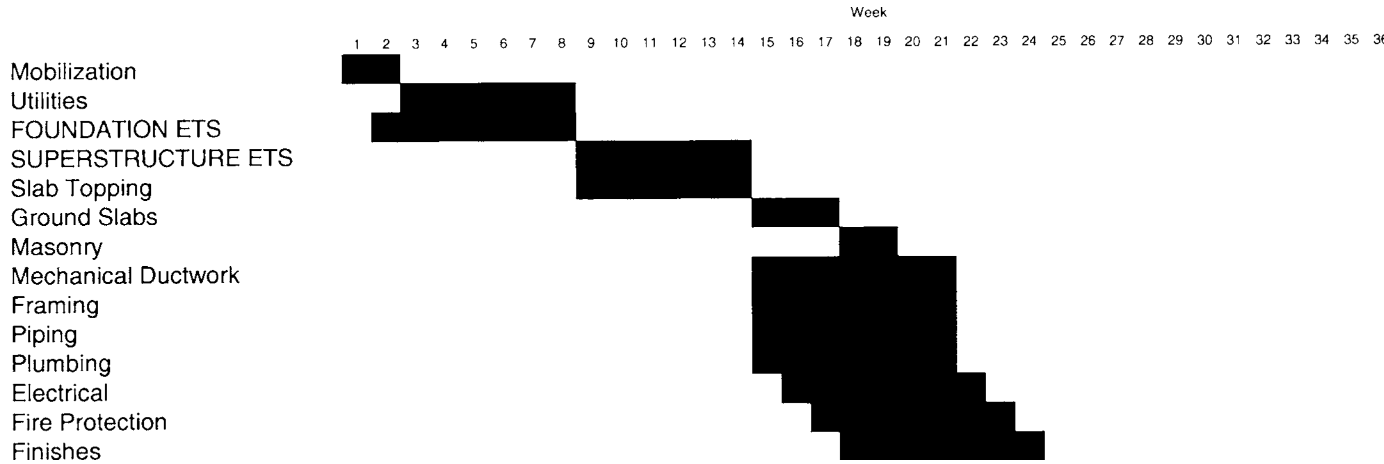

Fig. 11. Final execution plan

add or delete *x*, then I will increase or decrease my bid by *y* amount. If an alternative is accepted, any design changes are now the obligation of the owner. The contractor has invested little of his/her own financial resources to propose the change and any time delays are the responsibility of the owner.

Design–Build

Placing design and construction responsibility with a design–build contractor provides an ideal opportunity for construction input into the design. Teaming arrangements may vary from a single design–build firm, or a partnership of a designer and a contractor. However, in all cases the construction team is engaged with the project early in the design process.

Construction Manager

The construction manger approach to project delivery also makes construction expertise available to the design process. The construction manger's primary responsibility during design development is to provide construction input. This construction input is particularly important to the construction manager at risk, who will assume the role of a prime contractor and construct the project.

Finalize Execution Plan

It is important that the operational plans be compatible with the final execution plan. Since the operational plans are more specific, the preliminary execution plan should be updated. The updated plan becomes the final execution plan. This plan should show that the project can be completed within the time allowed by the contract.

Fig. 11 incorporates the retrospective schedule information from Figs. 8 and 10 and results in another shortening of the schedule to 24 weeks. As before, all activity durations remain unchanged.

Communicate and Enforce Plan

How the plan is communicated to others is of some importance. The means should be simple and clear. No doubt should be left as to what is to be done and when. A simple bar chart like the one shown in Fig. 11 is generally sufficient. If this plan is not enforced, the project will probably turn into a disaster. Fig. 12 is a sample form that can be used to communicate the details of the operational plan.

Applicability to Construction Practice

The principles and process presented in this paper have broad and immediate applicability to construction practice. Following these procedures will alleviate many practices that have been documented as causing poor labor performance relative to cost, schedule, and productivity. The principles presented are easy to understand and observe and easy to implement by practitioners. They will produce immediate and positive results. There are no "black-box" solutions and there is no need to master intricate scientific modeling principles.

Conclusions

Based upon years of experience of measuring site productivity and monitoring site operations, the writers have concluded that many small to medium size contractors do a marginal job of prebid planning. Bolstering these observations is the fact that in 30 years of monitoring construction sites, the writer has never observed a detailed operational plan or a site layout plan. Unfortunately, there is nothing in print that defines a process that a contractor should follow.

This paper has proposed an eight-step prebid planning process. Several tools for developing operational plans were also reviewed. It is hypothesized that better planning will improve cost performance and shorten construction schedules. Better planning can assure continuity in the utilization of key resources. Reduced downtime of labor resources is another benefit.

The planning process described calls for the planner to identify the sequences essential to success. In doing so, contractor planning resources are optimized and the likelihood of finishing on schedule is enhanced. Lag times or time buffers are important to efficient labor productivity. How to estimate lag times was illustrated.

By applying a few simple planning principles, the preliminary execution plan (retrospective schedule) for the sample project was shortened by approximately 30% (from 36 weeks to 24 weeks).

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OPERATIONAL PLAN

Project: SCMB Date: Jul 6, 2005
ETS Sequence: FOUNDATION
ETS Activities: Excavation-Rock Removal-Footings-Concrete Wall

Description of Work:
Excavation—all earth to elev. 908.5
Rock Removal—removal of dense, hard limestone in trench to elev. 906.5; Approx. 350 ft. Trench is 2'-8" wide; rock is anticipated throughout entire perimeter
Footings—conventional footing concrete walls—conventional 9" thick walls, to be placed in summer months

Methods and Resources:
Excavation—will be done via zones with one excavation crew supported by a front-end loader. Dump trucks will haul the spoil to the McHenry site (4 miles); no spoil is to be stockpiled on site. An earthen ramp is to be build to gain access to the basement area, but it is to be removed once excavation is complete. The excavated basement area will be used for rebar and formwork storage. Movement of materials is to be done via crane. Approx. excavation = 3,000 CY.
Rock Removal—the rock in the footing area is hard limestone (% recovery = 90%). The work will proceed at two workstations at opposite corners of the site. The removal of rock will be done with conventional jackhammers. This work is to begin one day after the corner of the footprint is exposed. Rock removal will be done with two teams of two laborers each.
Footings—this work will utilize conventional methods to construct built-in-place footing forms. There will be one team consisting of three carpenters.
Wall Formwork—this work will rely on conventional methods. One crew of six carpenters using 12' x 18' gang forms will accomplish this work.
All Work will be done in accordance with the schedule shown below.

Schedule: Duration: 36 working days

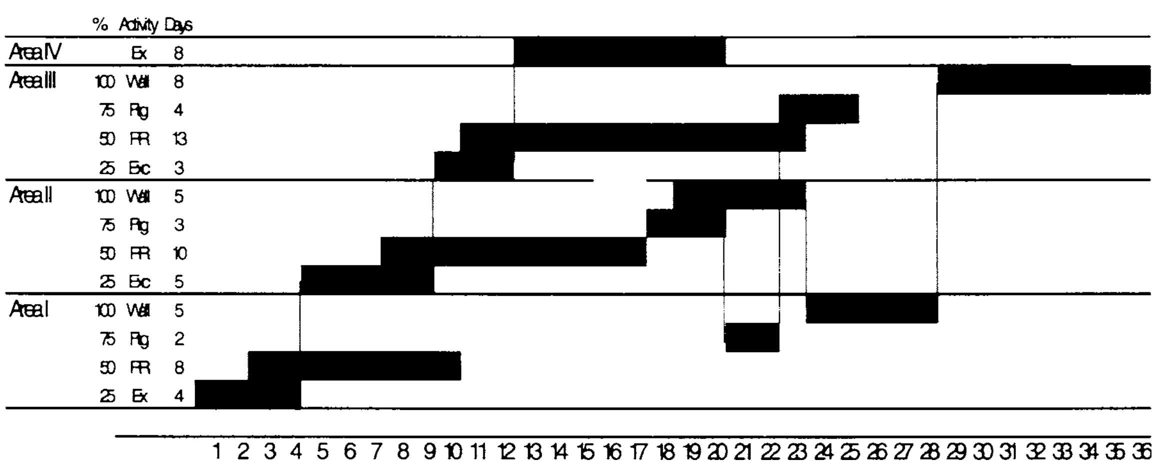

Fig. 12. Sample operational plan communication form

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