CHAPTER 6
BASIC SCHEDULING

This chapter continues the nuts and bolts of making the planning system work with regard to scheduling. The chapter shows exactly how to do the scheduling.

In actual practice, it may be helpful to note that persons may consider scheduling a somewhat vague term. To be more precise, *advance* or *weekly scheduling* means a scheduler allocating an amount of work orders for a week without setting specific days or times to begin or complete individual work orders. Likewise, *daily scheduling* means a crew supervisor assigning specific work orders to specific individuals to begin the next day. A maintenance group uses both weekly schedules and daily schedules. This chapter describes the activities to accomplish weekly and daily scheduling. In addition, the chapter covers how maintenance personnel stage material and tools. Although this book focuses on routine maintenance, the book also explains key scheduling concepts behind successful outages. Finally, the chapter compares and contrasts the concepts of scheduling with the concepts of quotas, benchmarks, and standards.

WEEKLY SCHEDULING

The scheduler performs most of the tasks of advance scheduling. The scheduler first gathers jobs from the waiting-to-be-scheduled file and any work returned from the previous week's schedule. The scheduler then allocates them into each crew's work hour forecast for the next week. The scheduler allocates jobs by work order priority, then number of work hours, but also makes other considerations per the scheduling principles. The scheduler utilizes scheduling worksheets for assistance. The end product is a package of jobs that the crew should be able to complete the next week. The scheduler then delivers the jobs for each crew to the crew supervisor. The scheduler also sends a copy of each work order that will need intercraft coordination to the supporting craft.

Each day the crew supervisor makes the daily schedule mostly from the work orders allocated in the weekly schedule. The crew supervisor assigns work to individual crew members based on the current day's activities and progress on work. The supervisor attends a daily scheduling meeting with other craft supervisors and the operations group representative to coordinate work for the next day. Near the end of the week, the crew supervisor returns to the scheduler the jobs that he or she does not expect the crew to start that week. The scheduler then considers them for inclusion in the advance schedule then being prepared.

Here are the step-by-step actual activities for weekly scheduling. This is the type of physical process which must be understood and which a computer CMMS would mimic.

Forecasting Work Hours

Each crew supervisor forecasts the crew's available work hours as the first step in the advance scheduling process.

This activity takes place near the end of the work week, usually at the beginning of the last shift for the period already in progress. For example, this would be Friday morning for a crew that works Monday through Friday, 8-hour day shifts or Thursday morning for a crew that works Monday through Thursday, 10-hour day shifts.

Near the end of the work week, the scheduler takes a Crew Work Hours Availability Forecast worksheet (shown in Fig. 6.1) to each crew supervisor. Taking the availability forecast worksheet to the supervisors impresses upon the supervisors that next week they will be responsible for completing the amount of work for which they have labor. They are involved in the process. The scheduler is only helping them determine how many and which jobs should be selected from the backlog.

The Crew Work Hours Availability Forecast worksheet has blanks to guide the crew supervisor in determining how many hours each craft level has available. This section and the following sections illustrate the crew supervisor's use of this form.

The crew supervisor fills out and returns the availability forecast worksheet as soon as possible after receiving it from the scheduler. The supervisor receives the forecast worksheet from the scheduler at 8 AM. The crew supervisor should already have an idea of who will be in training and who has requested vacation for the next week. On the other hand, the supervisor may need to check on jobs currently in progress to determine which ones the crew will probably not finish this week. Those jobs will need carryover hours reserved for them next week. In addition, the supervisor needs to assess which new jobs the crew will start today. Some of these jobs might be finished or might also run over into next week. One thing the supervisor does not plan for is unexpected absences. Scheduling is not based on the unexpected. The supervisor may later use unexpected absences that occurred to explain why the crew did not meet a schedule. When the crew supervisor finishes these determinations, he or she gives the scheduler the completed Crew Work Hours Availability Forecast worksheet. The crew supervisor also hands over any physical work orders which the crew received to do this past week, but will not start. The crew supervisor makes all these determinations by 10 AM and returns the worksheet. This gives the scheduler time to create the weekly schedule by 1 PM after lunch. (The scheduler must finish the weekly schedule by early afternoon so that the crew supervisor can make a daily schedule for the first day of the coming week. The crew supervisor must attend a late afternoon daily scheduling meeting to give the operations group information on clearances for the beginning of the following week and initiate coordination with other crafts, if necessary. The supervisor may also begin to make individual technician assignments.)

The maintenance group can easily computerize the availability forecast worksheet. Many CMMS packages contain work calendars for the crew supervisor to update crew member availability for the coming work days. Then the scheduler can access the data whenever needed. Of course, the crew supervisor must keep the data current. Even without a CMMS system or CMMS labor calendar module, the company can use a computer network. The scheduler can make a form on email or attach a spreadsheet program or word processing document with a representation of Fig. 6.1. By exchanging this form back and forth by email, the crew supervisor and scheduler produce the necessary forecast information.

Without getting current information from the crew supervisor, the scheduler might use a standard forecast of how many work hours were normally available. In other words, the scheduler would presume for a given crew that a certain number of labor hours were available every week. This standard forecast might presume that for a 10-person crew, one person would be unavailable for one reason or another. So the scheduler would schedule for nine persons each week. The scheduler and the crew supervisor would meet together occasionally to assess any needs to adjust the standard. The problem with using a standard forecast is that crew supervisors may not take the resulting schedule seriously. Whether or not they finish all their scheduled work, they will get the same amount of new work the next period. There is not much attention to carryover work which could be a significant problem. This approach figures that carryover work from the previous work remains about the

CREW WORK HOURS AVAILABILITY FORECAST

For week of: ___/___/___ **to** ___/___/___

For crew: ____________ **By:** ____________ **Date:** ___/___/___

Craft	# Persons		Paid Hrs		Leave		Train		Misc		Carry-over*		Avail Hrs
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
______	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Totals	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____

***Carryover work is any work which has been physically started in the current period, but will not be finished and will run over into the forecast period.**

FIGURE 6.1 Worksheet to assist crew supervisors forecast how many labor hours are available for scheduling work the following week.

same each week. Carryover work would be work that the crew started the previous week but did not complete. One of the main reasons to base weekly scheduling on a precise weekly forecast is to facilitate communication about performance. Scheduling to a standard forecast hinders achieving this purpose. Nonetheless, this approach may be necessary in situations of extreme crew reluctance and minimal management support.

Figures 6.2 and 6.3 illustrate the use of the Crew Work Hours Availability Forecast worksheet for a mechanical maintenance crew working a 10-hour shift. B. Jones, supervisor of A Crew, has just received the availability forecast worksheet from the scheduler. The crew consists of five persons: one skilled welder, one apprentice, one painter, and two mechanics. Jones feels that one of the mechanics possesses a very high degree of mechanical skill, but the other mechanic is significantly less capable at the present time. Jones knows that none of the crew will be in training any of next week, but the painter will be off 2 days for vacation. Jones considers the current jobs in progress. The welder's current job will not be finished today and requires about 5 hours next week to finish. The higher skilled mechanic has been working a job for the past 2 days and claims it will take 5 hours next week as well. The other mechanic will finish one job and start another job today that will also take about 5 hours next week to finish. The other crew members should finish their current work today as well. Jones plans to have them start and finish a new assignment. With this information, Jones estimates the total carryover work to be 5 hours of skilled welding, 5 hours of highly skilled mechanic work, and 5 hours of lesser skilled mechanic work.

Figure 6.2 shows that the supervisor begins completing the availability forecast worksheet by starting with a craft skill level listing for this specific crew. First, note that the worksheet considers apprentices simply as helpers. This plant does not regard apprentices as strictly in training for their craft and may utilize them where the high priorities of the plant lie. It is expedient to follow this philosophy in the forecasting phase of the scheduling, but to use the daily scheduling assignments to try to keep apprentices within their craft specialties. Second, note that the scheduler and the supervisor use the term mechanic to designate a fairly well-skilled mechanic technician. They use the term technician to designate a less skilled technician in the primary craft of the crew, in this case mechanical. This use of the terms allows planners, schedulers, and supervisors to communicate regarding skill level even within a standard classification. Although the plant does not have a certification program, significant differences between the skill levels of the mechanics exist. The plant needs to ensure not to allocate too many jobs requiring highly skilled mechanics at the same time. Normally a company could distinguish overall skill level through some certification process or a progression of rank such as third, second, and first class mechanics to identify the better mechanics. However, the subject plant has only mechanic, apprentice, and trainee formal designations. Therefore, the planners and schedulers informally address the needs for jobs by using the terms technician and mechanic on the job plans. When a planner uses the term technician, the job plan does not require a more capable mechanic.

Figure 6.3 shows the availability forecast worksheet after the supervisor enters all the quantities for persons and hours. Jones only forecasts for the 2 days of vacation approved for the painter. Supervisors do not presume there will be unexpected absences due to personal illnesses or sudden vacation day requests. The advance schedule sets a goal based on current knowledge and encourages everyone to meet the schedule. Typically, management above the supervisor directs training and special meetings. Management decides and sends various persons to different training classes or schools as well as coordinates special meetings such as safety or outage planning. Management does the crafts a great favor by scheduling these types of special events at least a week ahead of time. Once maintenance has set a weekly advance schedule, management assists maintenance in building the plant's confidence in the schedule by not encouraging deviation. Jones's management has not scheduled training or meetings for anyone. Jones's estimate of carryover hours is important because the scheduler must allow the crew time to finish jobs already in progress. The scheduler must not allocate new work for these labor hours. The supervisor's estimate of the amount of time required to finish carryover work is adequate. Finally, the supervisor completes the total's line for each type of work hour. The total's line helps in several ways. First, it helps to check the entries for accuracy of addition and subtraction. It also draws attention to how many hours exist in the various categories. The total magnitude of paid hours available to the crew and the effect of lost hours due to training or carryover work often are unappreciated. In this case, 200 labor hours represent a significant company expense. Out of this 200 paid hours, the supervisor forecasts 165 available for work next week in the shown crafts and skill levels. Finally, the totals lend themselves to tracking areas for improvement.

CREW WORK HOURS AVAILABILITY FORECAST

For week of: ___/___/___ **to** ___/___/___

For crew: ____________ **By:** ____________ **Date:** ___/___/___

Craft	# Persons		Paid Hrs		Leave		Train		Misc		Carry-over*		Avail Hrs
Mech	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Welder	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Machinist	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Painter	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Tech	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Helper	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
____	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
____	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
____	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
____	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____
Totals	____	x 40 =	____	-	____	-	____	-	____	-	____	=	____

***Carryover work is any work which has been physically started in the current period, but will not be finished and will run over into the forecast period.**

FIGURE 6.2 Input of normal craft and skill level designations.

Figure 6.4 illustrates the use of the Crew Work Hours Availability Forecast worksheet for another mechanical maintenance crew. J. Field, supervisor of B Crew, has just received the availability forecast worksheet from the scheduler. The crew consists of 15 persons. The crew has two welders, two machinists, and six mechanics. Field considers three of the mechanics to be significantly more capable than the others. Two trainees and three apprentices make up the remaining five employees. Field will forecast the crew available work hours from the following information. One of the welders requested 2 days of vacation next week. All B Crew apprentices must attend an entire day of classroom training. B Crew will have a 1-hour safety meeting on Wednesday. After checking on jobs in progress, Field makes an estimate for carryover work. Carryover work will

CREW WORK HOURS AVAILABILITY FORECAST

For week of: 5/10/99 **to** 5/13/99
For crew: A Crew **By:** B. Jones **Date:** 5/ 6/ 99

Craft	# Persons		Paid Hrs		Leave		Train		Misc		Carry-over*		Avail Hrs
Mech	1	x 40 =	40	-		-		-		-	5	=	35
Welder	1	x 40 =	40	-		-		-		-	5	=	35
Machinist		x 40 =		-		-		-		-		=	
Painter	1	x 40 =	40	-	20	-		-		-		=	20
Tech	1	x 40 =	40	-		-		-		-	5	=	35
Helper	1	x 40 =	40	-		-		-		-		=	40
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
Totals	5	x 40 =	200	-	20	-		-		-	20	=	165

***Carryover work is any work which has been physically started in the current period, but will not be finished and will run over into the forecast period.**

FIGURE 6.3 Completed forecast for the A Crew.

consist of 2 days of welding needing a welder and a helper, 1 day of machine work, 1 day of skilled mechanic work, and another day of less demanding mechanic work.

As before, the supervisor classifies the mechanics according to skill describing them as three mechanics and three technicians. The supervisor forecasts five helpers including the three apprentices and both trainees. The classroom training makes only 30 hours unavailable since out of the five helpers, only the apprentices must attend. The safety meeting on Wednesday makes 1 hour for each person unavailable for scheduling in the Miscellaneous column. The specific day of the week is irrelevant to both the forecast and the weekly allocation. Only the available hours for the entire week matter. The daily scheduling routine later will take this into account. Finally, out of the 600 paid hours, 455 are available for new work.

Sorting Work Orders

In preparation of allocating work orders into the crew availability forecast, the scheduler sorts the plant's backlog. If the crew is responsible for only a certain area of the plant, the scheduler will only sort those work orders. Later after all the scheduler allocates work for every crew, the scheduler might be able to recommend that certain crews assist other crews. The scheduler sorts the backlogged work orders in order to preferentially select work orders to allocate. If there are more job hours in the backlog than the forecast, obviously the scheduler cannot expect the crew to complete all the work. If the backlog has 1000 hours of jobs, then a crew expecting to have 455 labor hours cannot do all the work in a single week. The

CREW WORK HOURS AVAILABILITY FORECAST

For week of: 5/11/99 **to** 5/14/99
For crew: B Crew **By:** J. Field **Date:** 5/ 7/ 99

Craft	# Persons		Paid Hrs		Leave		Train		Misc		Carry-over*		Avail Hrs
Mech	3	x 40 =	120	-		-		-	3	-	10	=	107
Welder	2	x 40 =	80	-	20	-		-	2	-	20	=	38
Machinist	2	x 40 =	80	-		-		-	2	-	10	=	68
Painter		x 40 =		-		-		-		-		=	
Tech	3	x 40 =	120	-		-		-	3	-	10	=	107
Helper	5	x 40 =	200	-		-	30	-	5	-	30	=	135
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
		x 40 =		-		-		-		-		=	
Totals	15	x 40 =	600	-	20	-	30	-	15	-	80	=	455

***Carryover work is any work which has been physically started in the current period, but will not be finished and will run over into the forecast period.**

FIGURE 6.4 Completed forecast for the B Crew.

scheduler must select 455 hours worth of work to allocate for the week. The scheduler sorts the backlog of work orders into an overall order that will help determine which particular work orders are appropriate. Note that this presumes Scheduling Principle 4, proceeding with a preference to schedule 100% of the forecasted crew work hours, not more (120%) or less (80%). The procedure for allocating the work hours into the backlog proceeds with assigning the higher priorities before the lower priority work. The procedure also makes allowance for jobs on the same system and proactive work. In addition, the process shows how to select among jobs of equal priority and work type.

The scheduler returns to the planning office after delivering the Crew Work Hours Availability Forecast worksheet for the crew supervisor to complete. The scheduler collects all the planned work orders for a particular crew from the waiting-to-be-scheduled file and organizes them on a conference room table. The scheduler sorts them into separate piles, one pile for each priority. The waiting-to-be-scheduled file might already have separate folders for each priority to facilitate this step. Appendix J describes the priority codes for the work order system. Then, the scheduler sorts each pile into a particular order.

The scheduler first sorts the highest priority pile, priority 1 (urgent). Note there are no priority-0 (emergency) jobs in the backlog. Emergency jobs would already be under way and so are neither planned nor scheduled. By definition, all priority-1 work is classified as reactive work. Why is this reactive work sorted ahead of any proactive work? The ideal situation would be to have only proactive work in a plant. The plant prefers doing lower priority, proactive work to head off emergencies and urgent work. However, priority-1 work is urgent. It must be addressed, usually to restore lost capacity or remedy an immediate threat to production. The purpose of proactive work is to head off any reactive work, but when proactive action has failed to prevent a reactive situation, the situation must be addressed. Maintenance must first schedule urgent work to restore the plant. However, lower priority, reactive work should wait until after equal priority proactive work. In giving general preference to proactive work in this manner, the incidence of reactive situations diminishes. Therefore, the scheduler considers priority-1 work, which is all reactive and urgent, first.

The scheduler sorts the priority-1 jobs into order with jobs requiring the highest total of work hours on top. When the scheduler later allocates the work orders, jobs with more total work hours are put in the schedule first. This will allow fitting smaller jobs of equal priority into gaps of time remaining during the allocation process. This gap fitting would be more difficult if the scheduler allocated smaller jobs first. The scheduler would have to allocate only portions of larger jobs unnecessarily. The scheduler makes an exception to this sorting for smaller jobs encountered if they belong to the same system as larger jobs already higher in the group. In that case, the scheduler physically removes the smaller work order from its natural order and staples it to the work order for the larger job in the same system.

Scheduling work together for the same system is important for several reasons. Productivity increases if technicians can move from one job to a nearby job on the same system. They do not need to lose time familiarizing themselves with a different system at the start of each job. They avoid having to demobilize, travel, and move personal tool boxes to a different site to set up again. Sometimes they can use the same scaffolding or insulation clearing to get to the work. There is also a psychological boost to remaining on the same system. Frequently the time between jobs is taken advantage of as being a logical time to take breaks or "rest a moment" even when the jobs only last an hour or less. When jobs are scheduled on the same system, there is a tendency to look at the entire system as a single job through which to proceed with minimal delay. On the operations or production side, combining same system jobs also helps improve plant operations. An operator prefers to clear up a single system a single time for several jobs. A less organized scheduling effort might have the operator clear up the demineralizer on Monday and Wednesday for two jobs that could have both been done on Monday. Then on Friday, when the maintenance group requests the operator to clear up the demineralizer a third time, the operator must refuse. The operator must explain that the plant is in jeopardy of not having enough water in its storage tanks. This scenario frequently occurs when no advance scheduling exists. The supervisor then assigns work by picking through the entire plant backlog for each next job. The scenario also can occur if the scheduler does not place the jobs together in an advance allocation. Unnecessarily clearing up a system multiple times wastes time and frustrates the operators.

Then the scheduler similarly sorts the priority-2 (serious) work orders by work order size, biggest jobs on top, with three exceptions. The first exception is that the scheduler puts all PM, preventive maintenance, jobs at the top of the pile. PM jobs are always prioritized as priority-2 jobs. They are considered serious and not simply routine maintenance with a lower priority. The scheduler sorts PM jobs by job size within themselves, larger ones first. The second exception is similar as for priority-1 work orders. If a work order is encountered that belongs in a system for which a larger or higher priority work order has already been sorted, the work order is moved up and attached to the previously sorted work order. This is done even if it means moving a work order from the priority-2 pile to the priority-1 pile to attach it to the other work order. The third exception is that for work orders of approximately the same size with the same priority, the scheduler places a proactive work order ahead of a reactive one.

Then the scheduler sorts the pile for priority-3 work orders with larger work orders on top and proactive work getting preference for work orders of approximately the same size. The scheduler physically moves any work order for a system already encountered and attaches it to the other work order, even if it is in a higher priority pile.

Similarly, the scheduler sorts each pile of same-priority work orders. Finally, there is a finished group for each priority arranged from top to bottom by size. There are exceptions for same-system work orders stapled together, exceptions for similar-sized proactive work ahead of reactive work, and PM work orders at the top of the priority-2 stack (unless a PM was moved to the priority-1 stack to be with a same system work order).

Note that the advance scheduling process does not consider aging of work orders. The concept of aging is that an older work order should get higher attention than a similar work order only recently written. That is, a low priority work order written 9 months ago might justify more attention than a serious work order written only yesterday. Aging might help a work force that does not have weekly scheduling. If a crew is only completing the high priority work with low productivity, increasing the relative priority of an older, low priority job might encourage the crew to include it as well. Aging is not as helpful if the maintenance group allocates and expects a crew to complete a proper amount of work each week. A properly sized maintenance crew is capable of handling all the work that comes up, not just the high priority tasks. That means that the crew can complete all the work so aging is not necessary to bring older jobs to the top. Scheduling keeps the crew from lowering its productivity to handle only the high priority work. Scheduling Principle 2 states the importance of correct priorities. Working lower priority jobs ahead of clearly more important jobs leads a crew to doubt its leadership. Doing the most important work first gives the plant more benefit by definition. So aging is really a tool to increase a crew's low productivity. Aging would interfere with an already highly productive crew. Aging figures that a crew is less productive than it should be. Aging figures that a crew is only doing the high priority work by choice. So aging simply raises the priority of some of the work into the higher priority work to which the crew will give attention. On the other hand, a crew already getting as much work done as it should can only give attention to another job by not doing a job already intended. So aging for the highly productive crew has just made the crew complete a lower priority job instead of a higher priority job to the plant's detriment.

Claiming that less important work should not be done ahead of more important work does not say work should never be reprioritized. If an older, low priority work order for some reason merits more importance recently, then the priority should be increased. With the same reasoning, perhaps a higher priority work order is now less important than previously thought. The planning system should allow for changing the priority of each of these type work orders. One of the helpful additions to a planning group in this respect is an operations coordinator. This person or any knowledgeable operator can benefit a planning group by a monthly review of an extensive backlog. The operations coordinator can determine if some work orders should be reprioritized. This person has the authority to change the priority of any work order on the spot.

The scheduler receives two things from the crew supervisor a few hours after the last shift starts. The scheduler receives the completed Crew Work Hours Availability Forecast worksheet and any work orders which had been scheduled, but are now not going to be started this week. The supervisor has had time to assess the crew projected attendance for the next week as well as the status of current jobs-in-progress. In the case of an entirely paper-driven system, the crew supervisor physically hands over the work orders that the crew will not start. (In the case of an entirely computer driven system, the maintenance group might only print out the physical work orders when assigning them to the field technicians, if at all. The supervisor updates the computer changing each job to "in-progress" at the beginning of the shift or the end of the previous shift for the coming day. Therefore, the scheduler may consult the CMMS each week to determine which allocated jobs will not be started.) The scheduler takes the jobs not to be started and places them into the priority piles of work orders if they have already been arranged. The scheduler places these new work orders into the piles where they would belong if they had already been in the backlog. The actual allocation sequence can now take place.

Tables 6.1 through 6.3 illustrate sorting a plant backlog. The backlog belongs to mechanical maintenance A Crew. An earlier illustration used this crew as an example for forecasting. Table 6.1 shows the backlog arranged by work order number. The backlog consists of 243 total estimated work hours as planned. Because A Crew has only 165 work hours forecasted available, the scheduler must select the proper 165 hours to allocate for the next week. A plant also generally prefers to have 2 to 3 weeks of backlog available. This plant has less than 2 weeks of backlog. If this shortage is the normal case, the plant might not be identifying enough corrective maintenance situations to head off later breakdowns. The plant might also not be creating enough PM tasks. On the other hand, the maintenance crew might be overstaffed for the work area. Of the work orders in the backlog, work order codes as defined in App. J define certain information necessary for scheduling. First, the unit code N01 shows that most of the work orders are for North Unit 1, which is A Crew's primary responsibility. Second, within Unit 1, the system codes show that a variety of different systems need work. Third, work type codes indicate the nature of the work. Code 5 is breakdown and failure. Code 7 is preventive maintenance. Code 8 is work recommended by predictive maintenance. Code 9 is corrective maintenance that can head off failure and breakdown. Fourth, outage code 0 illustrates that the scheduler considers only work not requiring an outage of the entire unit for the normal work week.

Table 6.2 shows the backlog after the scheduler has physically grouped the work orders into different priorities. In addition, the largest work orders have been placed ahead of smaller jobs within each priority group. Note the scheduler places WO (work order) no. 012 requiring 16 total labor hours ahead of WO no. 004 requiring only 14 hours. Similarly, WO no. 004 is ahead of WO no. 002, which requires only 10 labor hours. Each priority group is similarly arranged with the only exception being for the priority-2 work orders. The scheduler must place PM work orders first within the priority-2 work orders. Work type code 7 defines the work as preventive maintenance. Therefore, the scheduler places WO no. 005 at the head of the priority-2 group even though it has the fewest hours.

Table 6.3 shows the backlog after the scheduler has adjusted the groups considering same-system work and other proactive work. First, the scheduler takes WO no. 006 from the

Attachment 1a

TABLE 6.1 Plant Backlog for the A Crew Listed by Work Order Number

WO No.	Unit	System	Priority	Work type	Outage	No. of persons and craft	Est. hours	Est. duration
001	N00	ZE	4	5	0	1 welder	35	35
002	N01	CP	1	5	0	1 tech	10	10
003	N01	CV	3	9	0	1 painter	40	40
004	N01	FC	1	5	0	1 tech, 1 helper	7, 7	7
005	N01	CP	2	7	0	1 tech, 2 helpers	6, 12	6
006	N01	FC	3	5	0	1 tech, 1 helper	15, 15	15
007	N01	JC	2	5	0	1 mech, 1 helper	20, 20	20
008	N01	JX	3	9	0	1 painter	4	4
009	N01	CP	4	5	0	1 mech, 1 helper	2, 2	2
010	N01	IF	3	9	0	1 tech, 1 helper	3, 3	3
011	N01	CD	2	8	0	1 mech, 1 helper	10, 10	10
012	N01	BV	1	5	0	1 welder, 1 helper	8, 8	8
013	N01	IF	4	9	0	2 tech	6	3

priority-3 stack and attaches it behind WO no. 004 in the priority-1 group. These work orders are both in the same system, FC. Second, the scheduler takes WO no. 005 from the priority-2 stack and WO no. 009 from the priority-4 group. The scheduler attaches both work orders behind WO no. 002 in the priority-1 stack. All three are in the same system, CP. Finally, the scheduler scans the work orders to see if any of the proactive work orders besides PM should be moved up in the allocation preference. Proactive work type 8 is work recommended by predictive maintenance and reactive work type 5 is work to restore something that has already failed. WO no. 011 (work type 8) is currently behind WO no. 007 (work type 5). If WO no. 011 were closer in size to WO no. 007, say 35 to 39 labor hours, the scheduler would move it ahead. However, in this case, the relative size dictates that preference be given to the reactive work. In the priority-3 group, all of the work is proactive, work type 9 so no adjustments can be made. The scheduler will use the order presented by Table 6.3 to select work orders to allocate into the A Crew work hours availability forecast.

Tables 6.4 through 6.6 illustrate another example of sorting a nonoutage, plant backlog for B Crew at the same plant. This crew has a different backlog because it is responsible for a separate section of the plant. Table 6.4 shows the backlog arranged by work order number.

Table 6.5 shows the backlog after the scheduler has sorted the priority groups and placed PM jobs at the top of the priority-2 work orders.

Table 6.6 shows the backlog after the scheduler has grouped same system work orders. This grouping should help maintenance and operations concentrate on the most needy systems in an organized manner. Notice this grouping also allowed the scheduler to move a number of proactive work orders up into the priority-1 group. There are seven proactive work orders moved into this group, two PM work orders, three corrective maintenance

TABLE 6.2 Plant Backlog for the A Crew Grouped by Work Order Priority, Size, and PM

WO No.	Unit	System	Priority	Work type	Outage	No. of persons and craft	Est. hours	Est. duration
012	N01	BV	1	5	0	1 welder, 1 helper	8, 8	8
004	N01	FC	1	5	0	1 tech, 1 helper	7, 7	7
002	N01	CP	1	5	0	1 tech	10	10
005	N01	CP	2	7	0	1 tech, 2 helpers	6, 12	6
007	N01	JC	2	5	0	1 mech, 1 helper	20, 20	20
011	N01	CD	2	8	0	1 mech, 1 helper	10, 10	10
003	N01	CV	3	9	0	1 painter	40	40
006	N01	FC	3	5	0	1 tech, 1 helper	15, 15	15
010	N01	IF	3	9	0	1 tech, 1 helper	3, 3	3
008	N01	JX	3	9	0	1 painter	4	4
001	N00	ZE	4	5	0	1 welder	35	35
013	N01	IF	4	9	0	2 tech	6	3
009	N01	CP	4	5	0	1 mech, 1 helper	2, 2	2

work orders, and one predictive maintenance work order. Without this grouping, the work force may have had a tendency to concentrate solely on the high priority reactive work for the week. A sanity check may also be needed after the forecast work hours are compared with the sorted backlog preference order. WO no. 023 is a fairly large priority-4 work order that the scheduler has moved into the priority-1 group. After reading exact job descriptions, the scheduler or operations coordinator may prefer holding it until the plant has addressed some of the priority-2 work. An obvious case might be the inadvisability of attaching a 40-hour, priority-4 job to a single 3-hour, priority-1 job. However, in the case of WO no. 23, there are already 67 hours of work to be done for system FO.

Allocating Work Orders

With the crew work hour forecast in hand and the work orders stacked on the table, the scheduler uses the Advance Schedule Worksheet, Fig. 6.5, to allocate the right work orders for the week. This worksheet allows the scheduler logically to connect the backlog with the crew time available. The worksheet form essentially consists of a blank sheet of paper with horizontal lines. The horizontal lines lie on the form at the same heights as the Crew Work Hours Availability Forecast worksheet (Fig. 6.1). The scheduler may tape or staple the schedule worksheet side by side to the availability worksheet. The scheduler places the worksheets together such that there is a long blank line immediately following the available work hours for each craft skill level. For the ease of this discussion, the scheduler does not physically attach the worksheets together, but writes the craft level and forecast available hours on the extreme left of each line. The long blank lines allow for tabulation of remaining crew hours as the scheduler places each job into the schedule allocation for the next week.

After writing the available hours on the left of each line, the scheduler selects the top work order from the pile of highest priority work orders. The scheduler uses the long blank line beside each craft skill level to write the remaining craft hours available after the scheduler subtracts the hours required by the selected work order. The scheduler then puts the selected work order into the week's worth of work being allocated. This work constitutes the weekly schedule.

The scheduler physically places the actual work order itself into a set of folders to deliver to the crew supervisor. There is a folder for each craft skill level which is the lead for the work order. For example, if the work order requires two helpers, the scheduler places the work order into the helper folder. If the work order requires a mechanic and a helper, the work order also goes into the mechanic folder since the lead person is a mechanic. If the work order requires two welders and an electrician, the work order goes into the welder folder since the bulk of the work (and probably the lead) is welding. Later these folders will help the crew supervisor find work while assigning to the different crafts and skill on the individual crew. The craft skill level folders not only allow sorting of the work by trades or classifications, but they are also the vehicle that physically transports the scheduled work orders over to the crew supervisor. Later at the end of the scheduling period, the supervisor returns the folders to the scheduler with work orders that were not started. The scheduler places these work orders back into the backlog for possible inclusion in the next weekly schedule as the scheduler follows the advance scheduling routine.

TABLE 6.3 Plant Backlog for the A Crew Adjusted for Work on Same Systems and Other Proactive Work

WO No.	Unit	System	Priority	Work type	Outage	No. of persons and craft	Est. hours	Est. duration
012	N01	BV	1	5	0	1 welder, 1 helper	8, 8	8
004	N01	FC	1	5	0	1 tech, 1 helper	7, 7	7
006	*N01*	*FC*	*3*	*5*	*0*	*1 tech, 1 helper*	*15, 15*	*15*
002	N01	CP	1	5	0	1 tech	10	10
005	*N01*	*CP*	*2*	*7*	*0*	*1 tech, 2 helpers*	*6, 12*	*6*
009	*N01*	*CP*	*4*	*5*	*0*	*1 mech, 1 helper*	*2, 2*	*2*
007	N01	JC	2	5	0	1 mech, 1 helper	20, 20	20
011	N01	CD	2	8	0	1 mech, 1 helper	10, 10	10
003	N01	CV	3	9	0	1 painter	40	40
010	N01	IF	3	9	0	1 tech, 1 helper	3, 3	3
013	*N01*	*IF*	*4*	*9*	*0*	*2 tech*	*6*	*3*
008	N01	JX	3	9	0	1 painter	4	4
001	N00	ZE	4	5	0	1 welder	35	35

TABLE 6.4 Plant Backlog for the B Crew Listed by Work Order Number

WO No.	Unit	System	Priority	Work type	Outage	No. of persons and craft	Est. hours	Est. duration
021	N02	BS	1	5	0	2 tech	6	3
022	N32	UA	3	9	0	2 tech	14	7
023	N00	FO	4	9	0	1 tech, 1 helper	20, 20	20
024	N00	HA	2	7	0	1 tech, 1 helper	20, 20	20
025	N00	HC	2	5	0	1 tech	17	17
026	N00	FO	2	5	0	1 welder	3	3
027	N00	HD	2	7	0	1 mach	2	2
028	N00	HP	1	5	0	1 mach, 1 helper	8, 8	8
029	N00	FW	4	9	0	2 helpers	12	6
030	N00	HD	1	5	0	1 mech, 1 helper	1, 1	1
031	N02	DA	3	3	0	1 mech, 1 helper	20, 20	20
032	N02	DO	3	9	0	1 helper	40	40
033	N00	FO	2	9	0	1 mach, 1 tech	14, 14	14
034	N00	FO	2	5	0	1 mach, 1 tech	6, 6	6
035	N00	KD	1	5	0	1 tech	20	20
036	N00	FW	1	5	0	1 mech, 2 helpers	6, 12	6
037	N00	FO	2	7	0	1 mech, 1 helper	4, 8	8
038	N31	UZ	2	5	0	1 tech, 1 helper	3, 3	3
039	N00	FO	2	8	0	1 welder, 1 helper	2, 2	2
040	N02	FD	3	8	0	1 welder, 1 helper	10, 10	10
041	N00	FO	1	5	0	1 tech, 1 helper	4, 4	4
042	N02	FD	1	5	0	2 tech	8	4
043	N31	UA	3	9	0	1 mech, 1 helper	20, 20	20
044	N31	UZ	4	9	0	2 helpers	2	1

The scheduler then repeats the work order selection process to allocate work orders into the available craft hours. The scheduler selects the next work order from the top of the highest priority work orders. If the selected job requires more hours than the hours left on a particular craft line, the scheduler must make a decision. The scheduler first tries to "work persons down," such as using a mechanic as a helper. The scheduler might want to schedule only part of a job, such as scheduling 30 hours of a 60-hour job if only 30 hours of a particular skill are available. The scheduler might also decide the job cannot be scheduled because there are insufficient hours available. The scheduler places subsequent work orders behind any work orders already in each folder. The scheduler continues the allocation process until either the crew runs out of available work hours or the backlog runs out of work orders. The backlog might run out of work orders altogether or just run out of work orders for which the crew has qualified labor.

After making the initial allocation grouping, the scheduler makes a final consideration of proactive work and consults operations. The scheduler considers if he or she ought to place

TABLE 6.5 Plant Backlog for the B Crew Grouped by Work Order Priority, Size, and PM

WO No.	Unit	System	Priority	Work type	Outage	No. of persons and craft	Est. hours	Est. duration
035	N00	KD	1	5	0	1 tech	20	20
036	N00	FW	1	5	0	1 mech, 2 helpers	6, 12	6
028	N00	HP	1	5	0	1 mach, 1 helper	8, 8	8
041	N00	FO	1	5	0	1 tech, 1 helper	4, 4	4
042	N02	FD	1	5	0	2 tech	8	4
021	N02	BS	1	5	0	2 tech	6	3
030	N00	HD	1	5	0	1 mech, 1 helper	1, 1	1
024	N00	HA	2	7	0	1 tech, 1 helper	20, 20	20
037	N00	FO	2	7	0	1 mech, 1 helper	4, 8	8
027	N00	HD	2	7	0	1 mach	2	2
033	N00	FO	2	9	0	1 mach, 1 tech	14, 14	14
025	N00	HC	2	5	0	1 tech	17	17
034	N00	FO	2	5	0	1 mach, 1 tech	6, 6	6
038	N31	UZ	2	5	0	1 tech, 1 helper	3, 3	3
039	N00	FO	2	8	0	1 welder, 1 helper	2, 2	2
026	N00	FO	2	5	0	1 welder	3	3
031	N02	DA	3	3	0	1 mech, 1 helper	20, 20	20
032	N02	DO	3	9	0	1 helper	40	40
043	N31	UA	3	9	0	1 mech, 1 helper	20, 20	20
040	N02	FD	3	8	0	1 welder, 1 helper	10, 10	10
022	N32	UA	3	9	0	2 tech	14	7
023	N00	FO	4	9	0	1 tech, 1 helper	20, 20	20
029	N00	FW	4	9	0	2 helpers	12	6
044	N31	UZ	4	9	0	2 helpers	2	1

TABLE 6.6 Plant Backlog for the B Crew Adjusted for Work on Same Systems and Other Proactive Work

WO No.	Unit	System	Priority	Work type	Outage	No. of persons and craft	Est. hours	Est. duration
035	N00	KD	1	5	0	1 tech	20	20
036	N00	FW	1	5	0	1 mech, 2 helpers	6, 12	6
029	*N00*	*FW*	*4*	*9*	*0*	*2 helpers*	*12*	*6*
028	N00	HP	1	5	0	1 mach, 1 helper	8, 8	8
041	N00	FO	1	5	0	1 tech, 1 helper	4, 4	4
037	*N00*	*FO*	*2*	*7*	*0*	*1 mech, 1 helper*	*4, 8*	*8*
033	*N00*	*FO*	*2*	*9*	*0*	*1 mach, 1 tech*	*14, 14*	*14*
034	*N00*	*FO*	*2*	*5*	*0*	*1 mach, 1 tech*	*6, 6*	*6*
039	*N00*	*FO*	*2*	*8*	*0*	*1 welder, 1 helper*	*2, 2*	*2*
026	*N00*	*FO*	*2*	*5*	*0*	*1 welder*	*3*	*3*
023	*N00*	*FO*	*4*	*9*	*0*	*1 tech, 1 helper*	*20, 20*	*20*
042	N02	FD	1	5	0	2 tech	8	4
040	*N02*	*FD*	*3*	*8*	*0*	*1 welder, 1 helper*	*10, 10*	*10*
021	N02	BS	1	5	0	2 tech	6	3
030	N00	HD	1	5	0	1 mech, 1 helper	1, 1	1
027	*N00*	*HD*	*2*	*7*	*0*	*1 mach*	2	2
024	N00	HA	2	7	0	1 tech, 1 helper	20, 20	20
025	N00	HC	2	5	0	1 tech	17	17
038	N31	UZ	2	5	0	1 tech, 1 helper	3, 3	3
044	*N31*	UZ	*4*	*9*	*0*	*2 helpers*	2	*1*
031	N02	DA	3	3	0	1 mech, 1 helper	20, 20	20
032	N02	DO	3	9	0	1 helper	40	40
043	N31	UA	3	9	0	1 mech, 1 helper	20, 20	20
022	*N32*	*UA*	*3*	*9*	*0*	*2 tech*	*14*	*7*

any more proactive work into the schedule to replace low priority, reactive work. This might be advisable for the allocation in which there is almost no proactive work whatsoever. There will never be a reduction of reactive work if there is never any proactive work performed. Both of the previous examples of backlogs contain a modest amount of proactive work and so need no adjustment. Next, the scheduler consults the operations coordinator giving this person a chance to replace any of the allocated work with work that the scheduler did not choose. Maintenance and production schedules must be integrated even when not considering outage work. The operations coordinator understands overall constraints of operations being able to clear or release certain equipment at the present time. The operations coordinator may also make final adjustments for the best benefit of the plant. In both of the example allocations, the operations coordinator decides not to make adjustments.

The following examples use the Work Order Allocation Worksheet to combine the previous forecast examples and previous backlog sorting examples into a week's worth of work, the weekly schedule allocation.

ADVANCE SCHEDULE WORKSHEET

For week of: ________ to __________
For crew: __________ By:_________ Date: ________

Forecast	**Available Hours Left**

Totals _____ _____

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.5 Worksheet to assist the scheduler determine which work orders to allocate for the week.

Figures 6.6 through 6.12 illustrate using the scheduling worksheet to allocate the nonoutage backlog for A Crew. The scheduler first copies the craft levels and forecasted hours from the Crew Work Hours Availability Forecast worksheet for A Crew (Fig. 6.3). Figure 6.6 shows the resulting Advance Schedule Worksheet after this first step.

Then the scheduler selects work order no. 012, the first work order from the highest priority group for A Crew (shown in Table 6.3). WO no. 012 requires a welder for 8 hours and a helper for 8 hours. Therefore, the scheduler subtracts 8 hours from the 35 hours available for welders leaving 27 hours available. The scheduler writes down "27" on the welder line indicating the hours now available. Similarly, the scheduler subtracts 8 hours from the 40 helper hours available and writes down "32" on the helper line to indicate there are only 32 helper hours now available. The scheduler places work order no. 012 into a folder labeled "Welder" for eventual delivery to the crew supervisor. Figure 6.7 shows the resulting Advance Schedule Worksheet.

Figure 6.8 shows the Advance Schedule Worksheet after the scheduler selects work order nos. 004, 006, and 002. The scheduler places all of these work orders into a folder labeled "Technician" because that is the lead skill required on each.

The scheduler then selects work order no. 005 from the backlog. This work cannot be allocated into the available hours as simply as the preceding work orders. This work order requires 6 technical hours, but there are only 3 technical hours available. The scheduler takes the 3 technical hours available and then takes 3 welder hours to use as technician hours. The scheduler considers that a welder can perform the less complex mechanical tasks required by a technician. The scheduler does not wish to use a more skilled mechanic for the work because the backlog contains a significant amount of priority-2, skilled mechanic work. The backlog has more welding work, but it is priority-4 work. Next, the work order requires 12 helper hours, but only 10 are available. Therefore the scheduler takes the 10 helper hours available and takes 2 more welder hours to use as helper hours. Thus the scheduler subtracts a total of 5 welder hours from the 27 available leaving 22 available welder hours. See Fig. 6.9. These decisions of where to take hours require judgment on the scheduler's part. The exact choices are not critical. What is critical is that the scheduler realizes the ability to allocate work to other than the exact craft and skill specified by the job plan. The scheduler must remember that the job was only planned for the minimum skill level required.

Another question arises regarding splitting hours from different areas. Is the scheduler requiring different persons to perform fractions of jobs? No. As the actual week later progresses, some jobs will run over and others under allowing the crew supervisor to assign whole jobs to specific individuals. The crew supervisor may assign a welder as a helper for an entire job, but probably not for only half of a job. Actual experience has shown that this method of allocating work for the week results in a quantity of work for which the crew possesses the appropriate labor.

As the scheduler selects more and more of the backlog, more of these type decisions are made. Figure 6.10 shows the results of the scheduler allocating work order nos. 009, 007, and 011 into the weekly schedule. For both WO no. 009 and WO no. 007 the scheduler has the mechanic hours needed, but has to use welder hours for all of the helper hours. For WO no. 011, the scheduler again has the needed mechanic hours available. However, the scheduler must again use another skill level for the helper hours required. This time there are no more welder hours available, The scheduler decides to use the painter as a helper for WO no. 011. Although there is painting work in the backlog, it has a lower priority than WO no. 011. The painter would still have some hours to begin the painting job and could finish it as carryover work the following week.

Finally, Figure 6.11 shows the last work order that the scheduler places into the weekly schedule. The scheduler does not want to overschedule the crew. WO no. 003 requires 40 painter hours. The scheduler expressly states by writing a note on WO no. 003 that only 10

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 to 5/13/99
For crew: A Crew By: C. Rodgers Date: 5/ 6/ 99

Forecast		Available Hours Left (Work Order #) #12
Mech	35	
Welder	35	27
Machinist		
Painter	20	
Tech	35	
Helper	40	32

Totals 165

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.6 Input of original labor forecast and first work order for the A Crew.

hours are being scheduled for the next week. The scheduler expects the painter to begin the paint job on the painter's last day of the week. The scheduler stops the schedule allocation process taking up all but 3 hours of skilled mechanic work hours from the forecast. There are no jobs in the backlog that take as few as 3 hours that the mechanic could perform. The scheduler has allocated 162 hours of backlog work for the forecasted 165 hours the crew has available. The scheduler considers this to be a 100% allocation. The scheduler does not want to give the crew any occasion to suggest that too much work was allocated. The scheduler now has work orders arranged in several folders, Mechanic, Welder, Painter, and

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 **to** 5/13/99

For crew: A Crew **By:** C. Rodgers **Date:** 5/ 6/ 99

Forecast		Available Hours Left (Work Order #) #12	#4	#6	#2
Mech	35				
Welder	35	27			
Machinist					
Painter	20				
Tech	35				
Helper	40	32			

Totals 165

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.7 Setting of columns to illustrate labor calculations with next three work orders.

Technician. The scheduler did not place any work orders in a folder labeled Helper because in this case, no work required helpers alone. The scheduler takes the work order folders over to the A Crew supervisor. A Crew supervisor Jones will use the work orders to begin establishing a daily schedule for the first day of next week.

In actual practice, Fig. 6.12 shows the actual worksheet as the scheduler would have filled in the information. The scheduler would not have listed each work order at the top of columns. Rather, the scheduler would have written in available hours left as the scheduler selected jobs and placed them into folders.

Attachment 1a

Figures 6.13 through 6.17 illustrate using the scheduling worksheet to allocate the nonoutage backlog for B Crew.

The scheduler first copies over the craft levels and forecasted hours from the Crew Work Hours Availability Forecast worksheet for B Crew (Fig. 6.4). Figure 6.13 shows the Advance Schedule Worksheet after the scheduler has selected the first 12 jobs from the previously sorted backlog for B Crew. None of the these jobs requires the scheduler to consider using a craft skill level other than the ones planned on the work orders. For each work order, the scheduler merely subtracts the required work hours from each craft skill level

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 **to** 5/13/99

For crew: A Crew **By:** C. Rodgers **Date:** 5/ 6/ 99

Forecast		Available Hours Left *(Work Order #)* #12	#4	#6	#2	
Mech	35					
Welder	35	27				
Machinist						
Painter	20					
Tech	35		28	13	3	
Helper	40	32	25	10		

Totals 165

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.8 Labor calculations of available labor hours remaining.

Attachment 1a

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 **to** 5/13/99
For crew: A Crew **By:** C. Rodgers **Date:** 5/ 6/ 99

Forecast **Available Hours Left**

(Work Order #)

	Forecast	#12	#4	#6	#2	#5	
Mech	35						
Welder	35	27				22	
Machinist							
Painter	20						
Tech	35		28	13	3	0	
Helper	40	32	25	10		0	

Totals 165 ______

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.9 Allocating first work order to use other than the minimum labor skill that was planned.

line. Then the scheduler puts the selected work order into its folder for the pertinent lead craft.

After including the twelfth job, WO no. 042, the scheduler runs out of room on the worksheet. The scheduler simply labels the worksheet "Page 1" and begins a second page. Figure 6.14 shows the second page and the next five work orders selected. Similar to the first page, none of the jobs requires the scheduler to consider using a craft skill level other than the ones planned on the work orders. For each work order, the scheduler subtracts the required work hours from each craft skill level line. Then the scheduler puts the selected work order into its folder for the pertinent lead craft.

Beginning with WO no. 25, the scheduler must decide to work persons outside of their top skill levels. WO no. 25 requires 17 technician hours, but only 9 are available. The scheduler decides to use 8 mechanical hours to make up the difference leaving 88 mechanic hours and 0 technical hours available afterward. Likewise, WO no. 038 requires using 3 mechanical hours as technical hours. There are no such decisions to make for WO no. 044

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 **to** 5/13/99

For crew: A Crew **By:** C. Rodgers **Date:** 5/ 6/ 99

Forecast **Available Hours Left**

		(Work Order #) #12	#4	#6	#2	#5	#9	#7	#11
Mech	35						33	13	3
Welder	35	27				22	20	0	
Machinist									
Painter	20								10
Tech	35		28	13	3	0			
Helper	40	32	25	10		0			

Totals 165 ______

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.10 Allocating next three work orders. Each uses other than the minimum labor skill that was planned.

Attachment 1a

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 to 5/13/99

For crew: A Crew By: C. Rodgers Date: 5/ 6/ 99

Forecast		Available Hours Left (Work Order #) #12	#4	#6	#2	#5	#9	#7	#11	#3
Mech	35						33	13	3	
Welder	35	27				22	20	0		
Machinist										
Painter	20								10	0*
Tech	35		28	13	3	0				
Helper	40	32	25	10		0				

Totals 165 3

*Only 10 hours of 40 hour paint job assigned. WO#003

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.11 Allocating a partial work order.

and WO no. 031. Each requires helper or mechanical hours which are available. Figure 6.15 shows the worksheet that results from including these four work orders.

Finally, Fig. 6.16 shows the resulting worksheet after the scheduler includes the last three jobs in the backlog. The scheduler uses the remaining 13 helper hours for WO no. 32. Since this work order calls for 40 helper hours, the scheduler also uses 27 machinist hours. This decision leaves 11 machinist hours and 0 helper hours. WO no. 43 calls for 40 technical hours of which none are available. Therefore, the scheduler uses 40 mechanical hours. Likewise, the last work order in the backlog, WO no. 22 is planned for technical hours. The scheduler uses mechanical hours instead. Now all the backlog has been allocated.

In actual practice, Fig. 6.17 shows the actual worksheet as the scheduler would have filled in the information.

Without the allocation system, the crew may have not realized it had the ability to complete the entire backlog. Instead, the crew may have only concentrated on completing the higher priority work. In addition, the allocation process identifies how many extra craft hours are left. There are 45 craft hours left, 11 mechanic, 23 welder, and 11 machinist. The scheduler has a basis to suggest using B Crew labor to assist A Crew next week. The B Crew Mechanic and Machinist could not only complete WO no. 010 and no. 013, but replace 10 of the helper hours on WO no. 007. This would free up 10 hours of A Crew

ADVANCE SCHEDULE WORKSHEET

For week of: 5/10/99 **to** 5/13/99
For crew: A Crew **By:** C. Rodgers **Date:** 5/ 6/ 99

Forecast		Available Hours Left
Mech	35	33 13 3
Welder	35	27 22 20 0
Machinist		
Painter	20	10 0*
Tech	35	28 13 3 0
Helper	40	32 25 10 0
Totals	165	3

*Only 10 hours of 40 hour paint job assigned. WO#003

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.12 Realistic completed Advance Schedule Worksheet for the A Crew.

ADVANCE SCHEDULE WORKSHEET

For week of: 5/11/99 **to** 5/14/99

For crew: B Crew **By:** C. Rodgers **Date:** 5/ 7/ 99

Page 1

Forecast		Available Hours Left (Work Order #)											
		#35	#36	#29	#28	#41	#37	#33	#34	#39	#26	#23	#42
Mech	107		101				97						
Welder	38									36	33		
Machinist	68				60			46	40				
Painter													
Tech	107	87				83		69	63			43	35
Helper	135		123	111	103	99	91			89		69	

Totals 455

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.13 Input of original labor forecast and first 12 work orders for the B Crew.

welder hours. Along with the 23 B Crew welder hours left over, this is almost enough hours to complete the priority-4 welding job, WO no. 001. There are two common practices to execute this assistance. One method would be for a crew supervisor to give the other supervisor several work orders. The other method would be for a crew supervisor to plan to loan the other supervisor several persons for a day or two. For example, presume that on the scheduler's recommendation, the A Crew supervisor gives the B Crew supervisor work order nos. 010 and 013. In addition, the B Crew supervisor arranges to give the A Crew one day of machinist help and two days of welder help toward the end of the week, if necessary.

Attachment 1a

STAGING PARTS AND TOOLS

Staging is not essential to maintenance planning. Planning and scheduling can achieve high productivity without staging parts and tools. Moreover, staging can be a time waster. Nevertheless, staging can significantly boost productivity for completing more work.

Staging means physically moving a part or a tool out of its regular storage place to where a technician can more easily obtain it before a job. Staging items reduces the time a

ADVANCE SCHEDULE WORKSHEET

For week of: 5/11/99 **to** 5/14/99
For crew: B Crew **By:** C. Rodgers **Date:** 5/ 7/ 99

Page 2

Forecast	*(Work Order #)* #40	#21	#30	#27	#24	Available Hours Left
Mech			96			
Welder	23					
Machinist				38		
Painter						
Tech		29			9	
Helper	59		58		38	

Totals ______ ______

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.14 Using a second page and allocating the next five work orders.

Attachment 1a

ADVANCE SCHEDULE WORKSHEET

For week of: 5/11/99 to 5/14/99

For crew: B Crew By: C. Rodgers Date: 5/ 7/ 99

Page 2

Forecast **Available Hours Left**

(Work Order #)

	#40	#21	#30	#27	#24	#25	#38	#44	#31
Mech			96			88	85		65
Welder	23								
Machinist				38					
Painter									
Tech		29			9	0			
Helper	59		58		38		35	33	13

Totals ______ ______

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.15 Allocating the next four work orders. The first two work orders use other than the minimum labor skill that was planned.

technician would otherwise spend gathering parts and tools before a job. A net reduction of time for the company comes from a combination of increased specialization, planner expertise, and reduced opportunity for delay trips. First, the person staging the part normally stages more than one job at a time, perhaps as many as needed for the whole crew. The employment of staging reduces the overall number of trips to the storeroom when handling several jobs at the same time. The person staging the items also gains a better than usual familiarity with the storeroom, further reducing time to procure any single item. Second, if

Attachment 1a

the person who plans the job also stages the items, there is another advantage. The planner who specified the item to begin with has the best idea of exactly what item the job requires. This familiarity may speed the process of obtaining the right part at the counter. Third, staging helps keep technicians on the job. Any trip away from the job to a storeroom or tool room can escalate beyond a simple delay to obtain the originally intended item.

Staging is similar to having the operations group clear a piece of equipment. The maintenance group prefers to have the equipment cleared before arriving on-site with three technicians. If the operations group did not have the equipment ready, the technicians would have to wait or lose overall efficiency finding other jobs to fill the wait time. Therefore, the operations

ADVANCE SCHEDULE WORKSHEET

For week of: 5/11/99 **to** 5/14/99
For crew: B Crew **By:** C. Rodgers **Date:** 5/ 7/ 99

Page 2

Forecast **Available Hours Left**

(Work Order #)

	#40	#21	#30	#27	#24	#25	#38	#44	#31	#32	#43	#22
Mech			96			88	85		65		25	11
Welder	23											
Machinist				38						11		
Painter												
Tech		29			9	0						
Helper	59		58		38		35	33	13	0		

Totals ______ 45

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.16 Allocating the final three work orders in entire backlog.

ADVANCE SCHEDULE WORKSHEET

For week of: 5/11/99 to 5/14/99
For crew: B Crew By: C. Rodgers Date: 5/ 7/ 99

Forecast		Available Hours Left
Mech	107	101 97 96 88 85 65 25 11
Welder	38	36 33 23
Machinist	68	60 46 40 38 11
Painter		
Tech	107	87 83 69 63 43 35 29 9 0
Helper	135	123 111 103 99 91 89 69 59 58 38 35 33 13 0
Totals	455	45

Instructions: Subtract job work hours from available line total until balance reaches zero for each line or backlog runs out.

FIGURE 6.17 Realistic completed Advance Schedule Worksheet for the B Crew.

group might normally clear the equipment during the night shift based on a request from the previous day's scheduling meeting or schedule. The technicians then arrive and go to work in the morning without delay. Likewise, the maintenance group prefers parts and tools to be ready for work. There might be overall inefficiency if two of the technicians have to wait for one technician to check out a special tool or wait in front of the storeroom counter.

Consider several tasks by a school maintenance person as an illustration of some of the benefits of staging. The school had identified a broken easel and a broken toddler table. The maintenance person serving several schools showed up at 11:00 AM. The school secretary handed over a bag containing a replacement bolt and plastic fitting for the easel and another bag with a washer and bolt for the table. The maintenance person took the staged items and fixed both pieces of furniture in 20 minutes. The school secretary had saved expensive maintenance service time by staging the parts needed. The secretary had determined what items were needed by simply examining the furniture and describing the problem to the appropriate school furniture supply company. This company had mailed the exact required parts the preceding week.

Consider another example from a modern electric power plant. The planner scoped the job to replace a flanged valve. The planner staged a sling, gasket material, and 48 bolts, washers, and nuts along with the replacement valve. The planner did not stage a necessary come-a-long as this device was standard issue in mechanic tool boxes. The planner placed all the items together on a pallet in the tool room. The planner identified the job as staged on the work order and attached a copy of the work order to the pallet to aid later identification. The two assigned technicians later transported the materials to the job site and expeditiously completed the work.

With staging in place, envision a technician arriving at work already knowing what job to start on from the previous day's schedule. The technician picks up his or her tool box along with a bag of parts staged the night before and heads to the job site.

The following sections discuss what might be practical to stage, where items could be staged, who should stage the items, and how to go about staging items.

What to Stage

The maintenance group should consider staging all the items the planner included in the job plan. When planning a job, the planner identifies the items that the planner anticipates the job requires. The key word is anticipated. Just as the planner includes time for only anticipated delays, the planner plans for only anticipated parts or tools. The planner estimates the anticipated job cost using these anticipated times, parts, and tools. The planner may include an equipment parts breakdown with the job plan, but this is only a list. The work plan expressly identifies anticipated items for this job. Therefore, it follows that if the job plan calls for certain items, those items could be staged.

However, a number of questions remain. What if it is uncertain what parts a job will need? Perhaps a high chance exists that the anticipated parts will be unnecessary. In addition, perhaps a high chance exists that unanticipated parts will be necessary. If there is a high probability that the technician will have to go to the storeroom for unanticipated items, why bother to stage the anticipated items the job will certainly require? Moreover, what happens to unused staged items on a job? What about time expended to return those items to stock?

Consider a technician that has already started a job where the planner has anticipated the use of several parts. The technician soon finds out the job requires only a single specific part. The technician can obtain just that item from the storeroom. Thus, there are no extra items taken to the job site and no leftover items to return. Why not have the planner just reserve the anticipated parts rather than stage them as well? Reserving through advance notice to the storeroom rather than the additional step of staging may be all that is needed.

As one can see, these questions complicate decisions regarding whether to stage items. Jobs vary just as do plant sites and plant processes such as receiving and returning storeroom items. Therefore, the following guidelines help the maintenance force make better decisions about staging.

Always stage anticipated items that are:

1. Nonstock and purchased especially for the job.
2. Certainly needed for the job and there is little likelihood any other items from the same place will be needed. *Example:* Job to replace air filter.

Favor staging anticipated items where:

1. There is high likelihood item will be needed.
2. There is low likelihood other items from the same place will be needed.
3. Technician time is valuable.
4. Technician time is limited.
5. Persons to stage items are readily available.
6. Equipment downtime is valuable.
7. Equipment downtime is limited.
8. Distance to the storeroom or tool room is excessive.
9. Availability or accessibility of storeroom or tool room is limited.
10. It is relatively difficult later to transport items to the site if they are not staged.
11. Item is easily returnable to storeroom or tool room.
12. Item is disposable if unused or lower in value than would be worth technicians' time to return.
13. There is some experience with planning and scheduling.
14. There is high maturity and sophistication of the planners to anticipate items correctly.
15. There is high confidence that the job will start the week or day scheduled.

Do not stage items that are:

1. For unscheduled jobs unless a nonstock item was exclusively obtained for a job.
2. Difficult or impractical to move repeatedly due to size or storage requirements.
3. Difficult or impractical to move repeatedly due to legal tracking requirements.

Scheduling is frequently the most critical factor influencing staging. Chapter 3 presented the case that if work could reasonably be expected to start in a given week, staging could be practiced. If there was no advance scheduling to tell when maintenance expected to start jobs, it might be impractical to stage parts or tools. One problem arises from taking parts or tools out of stock for a job that the maintenance crew may not start for quite a while. The staging makes the parts and tools unavailable for other jobs. The second problem arises from the physical storage of the staged parts and tools. Temporary holding places for staged items become overwhelmed and items become lost. On the other hand, if the maintenance group schedules a job for the next day or the next week, staging parts and tools can boost productivity. Staging a part or tool for a scheduled job makes sense because there is a commitment to starting the jobs. In that case, the staged items become properly unavailable for use elsewhere because they really do need to be reserved for jobs about to begin. In addition, because their jobs are about to begin, there is limited danger of overfilling a designated staging area.

Where to Stage

There are various possibilities for where the maintenance force may stage items, each with advantages and disadvantages. These possibilities include central staging areas, scattered staging areas, job sites, crew ready areas, and technician benches. Moreover, combinations of any of these approaches may be the most practical for a particular plant situation.

A central staging area would be an area where any item could be staged. The area could be part of another operation such as the tool room where technicians come to a counter to request their items. The area could otherwise be one dedicated for staging without a counter where some or all technicians have open access. Using a central staging area gives fairly good security to keep parts from being lost. Persons have little doubt where an item is staged because there is only one possibility. A central staging area lends itself to uniform procedures, especially with a counter operation. Unfortunately, the central staging area may not be better than leaving the items in the storeroom if the technician still has to go to a counter and wait for the attendant. Despite this concern, staging storeroom items in the tool room may still be a good idea. The maintenance group may have better control over the staging area than the storeroom. Many companies place the storeroom under the control of a group other than maintenance. The storeroom management may be unwilling or unable to make its checkout procedure user friendly. In this case, having a few persons stage the anticipated items out of the storeroom to a more readily accessible tool room for the bulk of technician activity makes sense. Geographic accessibility also makes a difference. The storeroom may be more remotely located than the staging area for most jobs. There may even be several storerooms scattered about the plant site for various types of goods. Having an efficient operation to stage items to a central location might increase overall efficiency. Technicians would not have to be as familiar with the various storerooms to obtain a part if they could go to a central staging area. A central staging area has several disadvantages versus other staging options. It may be better to stage items closer to job sites to speed up work. Also, a central staging area may still require the technicians to make a side trip. Each extra trip during the day invites technicians to add unnecessary delays. Technicians might check with the supervisor or technician friends "just to see what is going on." They might run by the machine shop to use the telephone "for a minute." Then the technicians must refamiliarize themselves with the jobs when they return. Mostly due to simple human nature, the delays add up when the staging area does not support technicians staying on the job site.

Scattered staging areas attempt to remedy the shortcomings of central staging. In this arrangement, there are several designated areas for staging. They are scattered throughout the extensive plant area. The locations are close enough to the general areas of work to avoid inviting any unnecessary side trips. They are also located out of regular traffic pathways, but easy to find. These staging areas are not necessarily elaborate and may be simply formed with lines of yellow paint. One aluminum rolling mill operation outlines squares of space on the plant floor in this manner. A more complex area might involve a shed. This is how one steam plant set up a staging area for specialized turbine tools on the turbine deck. Such a secure area may have a counter with an attendant and be open only during certain turbine work. At other times, limited access is available to supervisors or certain technicians. Other variations abound in between a secure shed with a counter and a painted square space. A shed, room, or cage could exist with or without a door lock or padlock. Large wooden boxes could be placed in strategic locations. Expensive or inexpensive shelving can be utilized. A closely associated issue is having access to tools at various locations throughout the plant. A particular job on a burner might require specialized tools that the plant uses nowhere else. It would make sense to have the burner tools located in a tool box on the burner deck ready for use whether a job is in the backlog or not. It could be argued whether this is scattered staging or a scattered tool room. In either case, the objective is to have items on hand to reduce travel and delays during the job. The disadvantages of a scattered staging strategy revolve around having less control and requiring more coordination. There is less security to prevent missing parts. It takes increased effort to take items to more than a single location. Nevertheless, having scattered sites close to the work areas can reduce delays to improve productivity.

Staging material directly at a job site provides the greatest advantage of not having to move parts repeatedly and limiting reasons to leave the job site. On the other hand, this arrangement provides the least security against missing parts. It could also contribute to a more hazardous plant site with parts located every which way. There is also danger for damaging items before they can be used if they get in the way of other plant maintenance or operations. The amount of coordination involved in finding each specific job site to receive items could be a further problem. Even with good coordination, there is a significant chance of putting an item at the wrong site and in effect losing it. On-site staging might make sense for a rotating spares program where there is a designated storage accommodation for the extra equipment. It is also practical to deliver large, nonstock equipment directly to the job site. It may also work out for items that are not readily transported later such as medium to large motors, valves, piping, and pumps. Note that the size of these items also makes it unlikely that they would be carried away from the job site. One plant makes the last duty of the day for tool room attendants to move heavy equipment such as cranes to the sites for the next day's jobs. Smaller items such as gaskets, small valves, and fittings are more practically staged in crew ready areas or on technician work benches.

The crew ready area is a likely place to stage relatively small items. Many crews have a designated area where they check in each morning. The crew may also use this area as a break room. Having a shelf or side area in this room for staged items reduces the need for an extra trip to a central staging location. This is especially true of the first job for the day and usually for a second and third job if breaks can be coordinated between jobs. The supervisor has some measure of control over such a location which may be an advantage over scattered locations or job sites. The supervisor also may be more interested in the staging operation with its visible presence there. A supervisor receives excellent feedback of how staging is working when the crew receives items in the supervisor's presence.

Technician benches cannot be overlooked as likely places to stage items. Many companies have a work area of sorts for every technician. This is especially true of many I&C technicians and electricians. It is also common for mechanics and other mechanical crafts to have work benches. These work places allow technicians a clean shop area to work on devices and equipment. Cleanliness gives a great boost to any maintenance task. Companies would rather a technician be free to concentrate on keeping gasket faces clean than to worry about where to obtain gasket material. Planning ahead to ensure parts availability and staging to deliver parts helps the technician's concentration. Technician benches are natural places to consider staging items. The technicians consider these areas their personal spaces and check in there just as they would their crew area each morning. In addition, technicians conduct many of the maintenance tasks in whole or in part on their bench. Therefore, staging items here might mean the technicians need not make any trips elsewhere. Consider a job to replace a gasket on a leaking flange. On this job, the technician needs to cut a gasket from a roll of gasket material. The planner has noted the size of the gasket needed as well as the gasket material. The day before the job, the supervisor has someone from the tool room drop off enough gasket material on the technician's bench for the job. The next day, the technician cuts the gasket, grabs rubber boots, and heads to the job site with the tools to fix the leaking flange. Drawbacks to staging on technician benches include a limitation on item size and possibly limited space available. The same coordination and security drawbacks of having multiple and scattered staging locations exist. An additional problem, unique to staging items at the technician benches, is that the person staging items must know the name of the assigned technician. The crew supervisor makes the assignments with the daily schedule. Because the weekly schedule does not identify the assigned technician, the person would not be able to use the weekly schedule to stage the items. Staging would have to be done daily from the daily schedule.

Who Should Stage

Normally the planner stages items, but there is equal opportunity for the scheduler, materials purchaser, tool room personnel, storeroom personnel, crew person, or even the supervisor to perform this function. Staging must not come ahead of other planning duties if management has excessively limited the number of planners. The materials purchaser is probably the best person to stage nonstock items received. In addition, if the staging is based more on the daily schedule than the weekly schedule, the supervisor or his or her designee would be more appropriate to do the staging. For simplification, the following section calls the person who does the staging, the staging person.

The Process of Staging

After the scheduler makes up the weekly schedule, the staging person reviews the scheduled work orders. This person might review them before delivery to the crew supervisors or later in the supervisor's offices. (Alternately the planner could review, and mark, the work orders and direct the staging person.) To avoid delaying the receipt of the weekly schedule by the crew supervisor, the staging person may find it more desirable to work from the crew supervisor's office. The person would also have better access to the work orders. The staging person marks the work orders for which items will be staged and makes a copy of each work order that will have staged items. Then, the staging person takes the work order copies to the storeroom and tool room and collects the items to stage. The staging person takes the collected items to the appropriate staging locations and attaches the work order copy to groups of items for each job. The person places items in appropriate containers such as bags for bolts and loose items, each marked for the appropriate work order. If there are several containers for the same work order, the staging person marks the work order copy as having four bundles and each bundle as 1 of 4, 2 of 4, 3 of 4, and 4 of 4, each with the work order number. These activities may take one or more trips.

The staging person must relocate the original work order for any items that were supposed to be staged, but could not be staged for some reason. The person marks these work orders accordingly. The staging process might discover an unexpected problem with item availability that will impact a job. In this case, the staging person informs the crew supervisor and planning so that the job will not be assigned until planning remedies the problem. In the case where the daily schedule is utilized, the same process is followed on a daily basis.

What happens to staged items for a job that is not started in its assigned day or allocated week? The items that were staged for this job are not collected and returned. It is presumed that this job will likely be assigned on a subsequent day or allocated in the next week's work. The job is simply considered already staged. This situation could get out of hand if jobs are routinely staged that never start. Staging areas could become overrun and inventory stocks could become depleted. This scenario is more likely for the plant that stages without any scheduling. Staging accomplished after some scheduling effort keeps these problems to an acceptable level. Daily staging for only the next day's work lowers the probability of these problems even further.

One thing to realize is that there is a limited time available to stage items. The difficulty comes in the timing because the advance schedule is only an allocation of work and does not denote which day activities might begin. If the staging person waits to use the advance schedule, there is not much work time after which the schedule becomes available before the work week begins. If the crew works Monday through Friday, 7:30 AM to 4:00 PM, the advance schedule would be available Friday afternoon for the staging person. The staging person could extend the work time available by working a weekend or evening shift to stage items. If the crew works another type shift, other times may work better. Consider a crew that works Monday through Thursday, 10-hour days. The staging person could work Monday through Friday 8-hour days and have Thursday afternoon as well as all day Friday to stage. In addition, if the supervisor prepares the first day's schedule soon after receiving the weekly allocation, the staging person could first concentrate on staging parts for that first day's work. Then the staging person could spend a small amount of time each day reviewing the next day's schedule from the supervisor and staging the appropriate parts.

In summary, staging can help improve maintenance productivity, but it is not essential to effective planning and scheduling. Furthermore, staging can become somewhat complicated to execute properly. Among a number of guidelines, scheduling control and experience dictate the successfulness of staging. Imagine a common household situation. One adult plans to hang several pictures and shock the swimming pool one night during the coming week. This person "stages" a hammer, several nails, and a bag of pool shock on a kitchen counter as the items are encountered during other weekend tasks. However, the items disappear from the counter as the week proceeds and wind up in various drawers or garage shelves. The person's spouse has put the items away to avoid clutter. The tasks of hanging the pictures and shocking the pool have become more complicated now as the location of the necessary items has become uncertain. Industry commonly experiences the same primary problems hindering these maintenance tasks, namely an improper staging area and an imprecise schedule for the work.

DAILY SCHEDULING

As discussed for Scheduling Principle 5 in Chap. 3, the crew supervisor schedules work orders on a daily basis. Formal daily scheduling assigns specific individuals to specific work orders in a manner that accounts for each labor hour available and works toward the goal of completing the work allocated by the weekly schedule.

Without formal daily scheduling, a natural tendency encourages supervisors to concentrate on higher priority work. Without something to encourage completion of lower priority work as well, most of the maintenance work started might be only the higher priority work. Supervisors might also tend to assign the more skilled technicians to this important work. This leads to a phenomenon of actually giving the less skilled technicians "busy work," many times work without a work order. These latter technicians might be sent to provide unneeded assistance on the higher priority jobs. They might also be allowed to take extra time on the jobs they are assigned. The supervisors desire to save the higher priority work for the higher skilled technicians. At the same time, the higher skilled technicians may see themselves as unfairly having to do most of the work. Consequently, the supervisors do not require schedule accountability. In short, productivity is left to the discretion of the high skilled portion of the work force to work at a reasonable pace on only the important jobs of the day.

In contrast, a formal, daily scheduling routine encourages the supervisors to focus on the completion of work orders rather than on keeping employees busy. The daily schedule routine ensures all technicians who work on work orders to be accountable to a schedule. The daily schedule makes sure everyone has a valid work order job. The daily scheduling routine encourages the supervisors to give the less skilled technicians greater challenge by not holding back jobs to save for other technicians. The daily schedule discourages the use of blanket accounts for time reporting because the daily schedule form plainly shows assignments. The daily schedule gives the supervisor a tangible tool with which to work toward the goal of finishing all the jobs scheduled for the week and showing what other work may have prevented them from meeting the goal. The daily schedule provides a means for the supervisors to keep track of all the jobs currently in progress and the jobs due to start the next day. The daily schedule requires the supervisor to consciously manage the crew. Having more jobs going on at the same time requires an attentive supervisor, as issues of personalities, working on jobs of more challenge, and more logistics problems arise.

The daily scheduling process begins with selecting work orders and assigning names, then coordinating with the operations group, and finally handing out the work order assignments.

Assigning Names

Different exact methods exist to schedule work for a single crew day. The important elements are that the scheduling method attaches particular tasks to each crew member's name and that the method fills each crew member's available work hours. For example, the crew supervisor should assign 10 hours of work to each crew member available for 10 hours. The supervisor bases the assignments on the planned estimates for the work orders. Depending on the industry, the supervisor might also denote the exact time during the day when each job should start or end. This would be more the case for a product line taken out of service with exact scheduling from the operations group. It would be less the case where operations can clear up certain areas for a day of maintenance without significant production problems. This chapter's outage section later addresses the urgency and coordination of outage work.

The crew supervisor normally schedules the daily maintenance activities for the crew. The scheduler might be able to do the operation of daily scheduling, leaving the supervisor free to manage work in progress and people issues. However, the daily scheduling is normally too integrated into the management of the crew for the supervisor to transfer away this duty.

Figure 6.18 shows a typical form that supervisors might use to assign names to work orders. The supervisor uses the form for a specific day. The form consists of a grid with spaces for work orders on the left and crew member names on the top. A single line near the bottom takes care of nonwork order time such as vacation. Codes allow identification

DAILY SCHEDULE
DAY:______ DATE:_______
SUPERVISOR:___________

WO#	Unit	Pri	Short Description																Comments
Special Code & Hours																			
Total																			

Special Codes:
V-Vacation S-Sick
T-Training O-Other
A-Assigned Off Crew

FIGURE 6.18 Form for daily scheduling.

of specific types of nonwork order time. The bottom line provides a space for totaling each technician's time. These totals help the supervisor assign enough work to fill each hour of the shift for each person.

Figure 6.19 shows how the B Crew supervisor has added the name for each member of the crew. The supervisor can add the names one time and then copy enough forms for a supply of preprinted, daily scheduling forms. The company's graphics department might publish these daily schedule forms in pads.

Figures 6.20 through 6.24 illustrate the use of the daily schedule form for B Crew using the previously developed Crew Work Hours Availability Forecast (Fig. 6.4) and the allocated backlog for the week (Fig. 6.17 and Table 6.6). First, Supervisor J. Field adds the day and date for the day being scheduled. Field is scheduling for Tuesday, the first day of the work week for B Crew which works 10-hour days. Figure 6.20 also shows the craft skill level for each person: M, T, S, W, and H for mechanic, technician, machinist, welder, and helper, respectively. Such designation is normally unnecessary because supervisors are familiar with their technicians' capabilities.

The supervisor first enters unavailable hours for different crew members. The supervisor marks the crew members who are unavailable for the next day for training, leave time, or other reason. The supervisor marks the form by placing the number of hours any employee is unavailable under the employee's name along with the proper reason code on the special code line. Field had approved 10 vacation hours for welder Hunter that day. Next, the supervisor adds any carryover hours from the preceding work day. The supervisor writes down the work order number and brief title of any carryover work that will run into this next day's schedule. The supervisor marks down the hours needed during the next day for carryover on the same horizontal line as the work order, but under each involved

DAILY SCHEDULE
DAY:______ DATE:________
SUPERVISOR:____________

WO#	Unit	Pri	Short Description	Adamson	Barber	Capper	Glade	Hunter	Jensen	Johns	Jones	Kingsley	Patterson	Richardson	Sanchez	Smith	Wilson	Young	Comments
Special Codes: V-Vacation S-Sick T-Training O-Other			Special Code & Hours																
A-Assigned Off Crew			Total																

FIGURE 6.19 Example preprinted form with crew member names.

Attachment 1a

DAILY SCHEDULE
DAY: Tues **DATE:** 5/11/99
SUPERVISOR: J. Field

WO#	Unit	Pri	Short Description	Adamson M	Barber W	Capper H	Glade M	Hunter W	Jensen T	Johns S	Jones T	Kingsley S	Patterson H	Richardson H	Sanchez M	Smith T	Wilson H	Young H	Comments
Special Codes: V-Vacation S-Sick T-Training O-Other			Special Code & Hours																
A-Assigned Off Crew			Total																

FIGURE 6.20 Input of date for the B Crew to schedule the first day of work week.

technician's name. Whenever the total hours for any individual reach ten, the supervisor writes 10 on the bottom line of the form. Figure 6.21 shows the results of these entries. Note that at this point, six persons of the 15 person crew have been assigned their entire 10 hours.

Next the supervisor must consider any urgent work that has come up since the time the weekly schedule was established. There may be several new urgent jobs that should not wait until the next week to begin. The supervisor adds to the daily schedule any urgent job that should begin that day. Such reactive work is planned, but planning on reactive work usually provides only an adequate scope and estimates of craft needs and work hours. This plan is all the crew supervisor needs to work the job into the schedule. With even a rudimentary plan, the supervisor keeps control of the schedule because planning has identified craft and time. The supervisor makes the decision to work these jobs into the current work load knowing that they will hinder the crew's completing all the weekly scheduled work. The supervisor would prefer to wait until the following week to begin all newly identified work for several reasons. First, jobs already scheduled for the current week have a greater likelihood of being staged leading to higher crew productivity. Second, waiting until next week gives the new jobs a better chance of having their items staged. Third, the current week's schedule was put together with some thought toward including all PM work plus sufficient other proactive work. The new job is reactive and will presumably keep proactive work from being done. Fourth, there is less chance to coordinate other resources such as other crafts. Management measures schedule compliance to encourage crews to get more work done. Working on the weekly allocation of work orders is a high priority for the crew supervisor. Nonetheless, the crew supervisor must redirect crew resources to work on truly urgent work for the good of the plant. The overall scheduling process is geared toward doing more work and doing more proactive work. However, the overall goal of the plant is not just better future availability, but availability in the immediate present as well. Urgent

DAILY SCHEDULE
DAY: Tues **DATE:** 5/11/99
SUPERVISOR: J. Field

WO#	Unit	Pri	Short Description	Adamson M	Barber W	Capper H	Glade M	Hunter W	Jensen T	Johns S	Jones T	Kingsley S	Patterson H	Richardson H	Sanchez M	Smith T	Wilson H	Young H	Comments
016	0	1	Boiler structure		10								10						Carryover
017	0	3	Fab pump shaft									10							"
019	2	2	Vacuum pump	10															"
015	2	2	Underdrains						10										"
Special Codes: V-Vacation S-Sick T-Training O-Other			Special Code & Hours					V 10											
A-Assigned Off Crew			Total	10	10			10	10			10	10						

FIGURE 6.21 Indication of craft skills. Input of unavailable crew hours and carryover work.

reactive work cannot be ignored. The crew supervisor must address those areas needing immediate attention. This reasoning is why the supervisor is responsible for daily scheduling and the immediate direction of the crew. The crew supervisor deviates from the weekly schedule when necessary and later explains such variances to management.

The supervisor does not have to consider emergency work when planning the next day's schedule. Crews always begin true emergency work immediately. If it can wait until the next day or the start of the shift, it may be urgent work, but it is not emergency. The supervisor immediately reassigns technicians from their current assignments for any emergency work. The supervisor makes note of these reassignments by marking up the current day's schedule, but there is nothing to mark on the schedule for tomorrow unless the current work will carry over. Then it is treated on tomorrow's schedule as carryover just as any job still in progress. If an emergency job were to come up in the middle of the night before the start of the next shift, the schedule would have already been completed. The supervisor simply revises the schedule as necessary to reflect the already assigned persons.

The weekly schedule still helps improve weekly productivity even when crews do not start scheduled work as a result of emergency or other urgent jobs arising. When reporting variance from the weekly schedule, it is difficult to explain why only one emergency job and three urgent jobs kept ten scheduled jobs from starting.

In the current illustration for B Crew, no emergencies or urgent jobs have come up for consideration in the current day's work or for the following day. This plant places an emphasis on preventing urgent situations. Personnel report small problems that can be handled proactively before they grow into large problems. Management discourages anyone including engineers from requesting work at the last minute that they could have identified earlier.

Next, the supervisor inspects the week's worth of work consisting of the folders with work orders. The advance scheduler had prepared these folders for each lead craft.

Attachment 1a

Generally the supervisor starts with the folder that represents the bulk of the crew. This folder has the most work since there were more persons for which the scheduler had to give work. The supervisor selects one job at a time and places the work order number on the daily schedule form along with a brief description of the work. Then the supervisor assigns the proper crew members to the job by allocating the work hour estimates under their names. The selection of jobs and assignment of persons is not an exact science. The supervisor prefers to consider higher skill work ahead of lower skill work to help keep assignment options open. Another preference the supervisor follows is to assign a large job to several persons, then keep those persons together for the day by assigning smaller jobs to fill their available hours. Selecting the larger, high priority jobs first leaves smaller jobs for fitting into schedule slots to make up a person's whole shift. The supervisor's skill in working with personalities comes also into play. This consideration is beyond the ability of the scheduler to make when creating a weekly schedule. Which crew members work best together? Which employees do not get along with each other? Which employees do not cooperate well with anyone? Which employees enjoy a certain type of work? Which employees need a challenge? Which employees possess the necessary skill to accomplish a unique, critical task? Which employees seem to need extra coaching and supervision? Which employees work best independently? Which employees need more experience working together with others? Which employees want opportunities to develop their leadership capabilities by leading larger jobs? Which employees rank high on the overtime list? These employees might be assigned to critical jobs that could run over requiring overtime. Which employees have the most familiarity with a particular system? Which employees need more experience in a certain system? Which employees need more experience developing a particular skill? Which employees most successfully knock out a series of small jobs? Which employees always seem to stretch their jobs to mid-day or to the end of the

DAILY SCHEDULE
DAY: Tues **DATE:** 5/11/99
SUPERVISOR: J. Field

WO#	Unit	Pri	Short Description	Adamson M	Barber W	Capper H	Glade M	Hunter W	Jensen T	Johns S	Jones T	Kingsley S	Patterson H	RichardsonH	Sanchez M	Smith T	Wilson H	Young H	Comments
016	0	1	Boiler structure		10								10						Carryover
017	0	3	Fab pump shaft									10							"
019	2	2	Vacuum pump	10															"
015	2	2	Underdrains						10										"
036	0	1	Unloading arms			6	6											6	
029	0	4	Dock gutters			4	4											4	
Special Codes: V-Vacation S-Sick T-Training O-Other A-Assigned Off Crew			Special Code & Hours					V 10											
			Total	10	10	10	10	10	10			10	10					10	

FIGURE 6.22 Input of the first two jobs from the allocated weekly backlog.

DAILY SCHEDULE
DAY: Tues **DATE:** 5/11/99
SUPERVISOR: J. Field

WO#	Unit	Pri	Short Description	Adamson M	Barber W	Capper H	Glade M	Hunter W	Jensen T	Johns S	Jones T	Kingsley S	Patterson H	RichardsonH	Sanchez M	Smith T	Wilson H	Young H	Comments
016	0	1	Boiler structure		10								10						Carryover
017	0	3	Fab pump shaft									10							"
019	2	2	Vacuum pump	10															"
015	2	2	Underdrains						10										"
036	0	1	Unloading arms			6	6											6	
029	0	4	Dock gutters			4	4											4	
Special Codes: V-Vacation S-Sick T-Training O-Other A-Assigned Off Crew			Special Code & Hours					V 10											
			Total	10	10	10	10	10	10			10	10					10	

FIGURE 6.23 Input of the next three jobs into daily schedule.

shift? The supervisor's knowledge of the crew allows taking these considerations into account when assigning the allocated work on a daily basis.

The supervisor should resist assigning more than the estimated hours on the work order. For example, if the work order has an estimated requirement of two mechanics for 6 hours each, the supervisor would put "6" under two crew member names, not "8" for each to fill up an 8-hour shift. The job may end up running over, but the supervisor does not want to begin by anticipating the job will consume the entire shift. The assignment of exact work order hours would be a good check area for concerned managers. Checking the daily schedule may indicate a problem with most jobs seeming to be always planned for 10 hours or scheduled for 10 hours just because that is the shift arrangement.

The supervisor continues selecting tasks from the folders and distributing their hours among the crew. A work order may be attached to other work orders for the same system. In this case, the supervisor prefers to assign all of the attached work orders to a larger group of persons for the same day rather than assigning them to a smaller group over several days. Working all the jobs for a single system at the same time shortens the time the system must be out of service. It also contributes to a sense of accomplishment for both the crew and the operations group when they complete all the work on a system.

The supervisor continues selecting tasks until all crew members have their available work hours assigned to work orders. After assigning a number of the work orders, the supervisor has to exercise some further judgment in selecting work orders. The best persons to which to assign a particular work order may have too few hours left in the shift to complete that work order. The supervisor is free to assign technicians to start a bigger job that they will not finish in the shift. If assigning a 10-hour job to a person with only 3 hours left available, the supervisor would place a "3" under the person's name across from the new job. The supervisor could also immediately begin the next day's schedule with the job at hand placing a "7" in the pertinent crew member box. That schedule may be adjusted later for different carryover hours when actual job progress is assessed. On the other hand, there may be smaller jobs with lower priorities, but fewer hours that could be completed on the same day. The supervisor is free to pick any of the jobs of lower priority in the week's allocation for assignment anytime during the week.

If the supervisor runs out of work from the weekly allocation, then he or she checks with planning to obtain planned work from the unscheduled backlog. This work is in the planning group's waiting-to-be-scheduled file. If there is no planned work waiting, the supervisor checks with the planner about working jobs that are not yet planned. The supervisor should resist assigning work without a work order.

The supervisor totals up each person's assigned hours under the person's name. The hours for each person should add to the person's paid work hours. For example, if 10-hour shifts are employed, then there should be 10 hours totaled up under every employee.

Figure 6.22 shows the first two jobs the supervisor has selected from the week of allocated work. The supervisor has selected the top job from the Mechanic folder. The supervisor first selects WO no. 36 requiring a mechanic and two helpers for 6 hours each. This work order has another work order attached for the same system. This second work order, WO no. 29, requires only two helpers for 6 hours each. After briefly reviewing the work order, the supervisor decides to assign it to the team of three persons doing the first job. The supervisor assigns each of them 4 hours to complete this job and makes a note on the work order. The supervisor has changed the plan of 12 helper hours to assign 8 helper hours and 4 mechanic hours. (This is a little unusual to change a plan in this manner, but it is acceptable.) Now three more persons have 10 total hours for the day.

DAILY SCHEDULE
DAY: Tues DATE: 5/11/99
SUPERVISOR: J. Field

WO#	Unit	Pri	Short Description	Adamson M	Barber W	Capper H	Glade M	Hunter W	Jensen T	Johns S	Jones T	Kingsley S	Patterson H	Richardson H	Sanchez M	Smith T	Wilson H	Young H	Comments
016	0	1	Boiler structure		10								10						Carryover
017	0	3	Fab pump shaft									10							"
019	2	2	Vacuum pump	10															"
015	2	2	Underdrains						10										"
036	0	1	Unloading arms			6	6											6	
029	0	4	Dock gutters			4	4											4	
028	0	1	Pump impeller							8				8					
027	0	2	Cat underdrain							2				1					
030	0	1	Trn Pump Align											1	1				
035	0	1	Piping								10								2 day job
031	2	3	Aux feed pumps												9		10		2 day job
025	0	2	Caustic leaks													10			10 of 17
Special Codes: V-Vacation S-Sick T-Training O-Other A-Assigned Off Crew			Special Code & Hours					V 10											
			Total	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	

FIGURE 6.24 Completed daily schedule for the B Crew.

Figure 6.23 shows the result of the next three work orders selected by the supervisor. The supervisor decides to start none of the FO, Fuel Oil Storage and Transfer System, work on Tuesday because neither welder is unavailable. One is involved with carryover work and the other is taking vacation. The supervisor selects WO no. 28 requiring a machinist and a helper and then adds a smaller job, WO no. 27, to finish up the machinist's hours for the day. Because WO no. 030 is on the same system, the supervisor assigns it next.

Next, the supervisor has 20 technician hours, 9 mechanic hours, and 10 helper hours available. The supervisor selects the large job, WO no. 35, requiring 20 hours for one technician to begin 10 hours. The supervisor also assigns a 40-hour job, WO no. 31, to the mechanic and helper to begin a total of 19 hours. Finally, the supervisor assigns a 17-hour job, WO no. 25, to the last technician, Smith, to begin 10 hours. After this scheduling, the supervisor finds that a single person has less than 10 hours assigned. The helper Richardson has only 9 hours assigned. The supervisor sees no single-hour helper jobs and is reluctant to have a helper begin another job alone that will carry over. Therefore, the supervisor adds the helper's last hour to the cation underdrain fabrication job, WO no. 27. This will give Richardson, an apprentice, some time in the machine shop. Figure 6.24 shows the completed daily schedule form with names for all crew members assigned to work orders with all shift hours accounted for, adding up to 10 hours each.

Coordinating with the Operations Group

With the schedule filled out, the supervisor then coordinates with the operations group. The supervisor must communicate with operations for two reasons. The supervisor first requests that the operations group clear the pertinent equipment for the next day. The supervisor must also determine if any testing is advisable as the maintenance crew returns equipment to service. Many plants conduct a daily schedule meeting each afternoon to coordinate the next day's work between these two groups. The meeting consists of the crew supervisors and the operations supervisor. At this meeting, maintenance may also advise regarding the progress of on-going work in addition to coordinating the start and testing of new work.

Clearing means that the operations group is making the equipment available and safe for maintenance work. For example, the operations group may clear the equipment by draining process lines and closing necessary valves and electrical breakers. Then, depending on particular plant policy, the maintenance personnel may follow behind and lock out valves and breakers to their own satisfaction and security. For simplicity, this book presumes the operators do all clearing and maintenance personnel do not perform separate locking. Companies with additional requirements would simply add their required procedures to the illustrative process described here. The company should have a standard process for the maintenance group to notify the operations group of clearance needs. With a daily schedule meeting, maintenance can hand over a printed clearance request form. The maintenance crew could also deliver a clearance request form at any time to the operations group. However, maintenance should keep in mind that the operations group also schedules their activities and desires timely advance notice. Plant policy might allow less formal notice as phone calls or emails to the operations group. The plant might utilize a CMMS computer to flag the backlogged work orders needing clearance for the operators. In a daily scheduling meeting, each crew supervisor gives operations a copy of the crew's proposed daily schedule and a printed clearance request form for each work order needing clearance. The clear request form should describe the work proposed along with times needed for clearance. A copy of the work order form with special clearance instructions makes a good clear request format because the operators see the actual, maintenance work document. The supervisor has the original work order forms in hand at the meeting instead of just the schedule sheet to allow reference to any planner notes regarding special circumstances. The face-to-face daily meeting allows the operators to commit to clearing up the necessary work areas during the evening shift for an around-the-clock operating environment. Otherwise, the operators can commit to when they would clear and have ready equipment the next day if they would not accomplish it during the night. At this meeting the operations group would also explain any particular requirements if it could clear the equipment for only part of the day. The supervisors also record feedback on the pertinent work order forms for new information regarding special requirements. The crew supervisors also note restricted times for maintenance work on the daily schedule forms and the work order forms which they will give to the field technicians. The operations group can also give immediate feedback for any jobs that it would not be able to clear at all. The supervisors make changes to the daily schedule if needed. The supervisor also has brought the weekly backlog of work to the meeting in case a new work order or two needs to be selected as replacements for jobs that would not be cleared.

During the daily scheduling meeting, the operations group and the crew supervisor agree regarding any special testing after job completion. For example, a particular strainer that has shown a past tendency to leak after maintenance should be tested before the technician has completely demobilized from the site. The decision of which jobs to test really depends upon the type of work done and the confidence in the maintenance skills and so would vary from plant to plant. The operations group or the maintenance group may have definite preferences for particular work orders to test. The planning group may recommend by noting within the job plans if the jobs should receive special attention. Management should establish a clear policy when possible regarding testing. The crew supervisor makes appropriate notes on the work orders which require testing after completion.

Handing Out Work Orders

After the daily scheduling meeting with the operations group, the crew supervisor publishes the daily schedule with any necessary revisions. The supervisor might do this by posting the daily schedule form on a crew area bulletin board or outside the supervisor's office. This allows individuals to think about their assignments for the next day. Spreading the news keeps crew members feeling more a part of a team. If published in time, there may be productivity improvements as well because technicians finishing their current jobs could take their tools and somewhat set up for their next assignments. The technicians could also review the job plans or technical manuals to familiarize themselves with the equipment. Technicians could even start to gather parts and special tools if they were not going to be staged. In effect, the technicians can stage their own jobs because they have advance notice.

The handing out of the physical work orders may depend on the plant's policy with respect to work permits. The operations group issues a document called a *work permit* that certifies that it has cleared the necessary equipment to allow safe maintenance work to begin. (Some jobs do not require clearance and work permits and the supervisor marks this information on the work order form if the planning group has not already done so.) There are different ways to accomplish permitting work areas, some less formal and some more formal and rigorous. The exact procedure would be dictated by company policy. The exact policy does not appreciably affect the enhancement to crew productivity of planning and scheduling. Some plants allow individual technicians to pick up the work permits for their assigned jobs. Other plants require the crew supervisor or a special designee to pick up the work permits. The process presented here of supervisors collecting work permits shows where the clearing and permitting of work fall into the overall planning and scheduling flow. This plant's supervisors do not hand out the physical work order forms yet because they do not yet have work permits for the jobs.

After the operations group clears the necessary areas, the operators write a work permit for each cleared work order. Then, it places the permit into a control room folder, box, or wall pocket for the crew supervisor to collect. The operations group removes a carbon copy from the back of each work permit to post on a control room bulletin board to provide the operations group with a visible board of jobs-in-progress.

At regular times the crew supervisors check the control room to pick up the approved work permits. The supervisors check for permits at the beginning and end of each day. Usually the supervisors arrive at the plant ahead of the crew to gather new work permits so that they can hand out respective work orders. They also check for permits as they return previously issued work permits from jobs completed during the day. The supervisor hands out the work order forms, but keeps the permits either in the supervisor's office or on his or her person.

The supervisor may physically hand the work orders out in a number of ways. A common practice is through a morning check-in meeting. The supervisor meets with the whole crew at shift start. The supervisor physically hands out work orders to the lead technicians making sure everyone knows where they will be working for the entire day. The supervisor may hand out all the work orders of the day or just the first ones, planning to distribute the rest of the work order forms as individuals, pairs, or groups of technicians near completion of their first jobs. The advantage to handing out all the work orders for the day at the beginning is that technicians can plan their pace for the day better. They understand the goal for the day. This factor probably outweighs a slight disadvantage for them having to keep track of the paperwork. A lost paper work order form would be a significant problem in an entirely paper system with no other record of the work. Arrangements where a computer database has at least a record of each work order make the problem of lost forms less important. Fully utilized CMMS computer systems have the least worry over lost paper forms where the computer record of the work order is the master and any paper copy serves only as a field device for the technicians. Of course, the trade-off becomes the risk of having the computer system available and functioning. Paperwork would be that much harder to keep up with, if emergencies frequently seem to interrupt work. Another common practice is for supervisors to pin work orders under lead technician names on a crew area or supervisor office bulletin board. Cubbies, file folders, or special mail slots can also be used for this purpose. Alternately the supervisor could write work order numbers on a dry erase board with lined columns and rows. Some supervisors, whether they have daily crew meetings or not, prefer personally contacting individual technicians throughout the day making sure each technician has the right work order and knows where the next assignment is.

Figures 6.25 and 6.26 illustrate possible aids for handing out work orders by placing them in slot or box structures. Everyone should be aware of work permit policies when setting up a system for technicians to have access to work orders. The following arrangements might be duplicated by writing work order numbers on dry erase boards. Figure 6.25 shows a cardboard, wooden, or metal mailbox arrangement. A supervisor might create tentative daily schedules for the entire week and distribute the entire allocated backlog. The supervisor might also distribute work orders for only one day at a time. One problem with a mailbox system is that a paper work order could only be placed in one box under a single name, usually the lead technician. Each column might be headed by a group of names or only lead technicians for teams. However, this presumes the same groups of persons would remain together throughout the week or longer. A dry erase board avoids this problem because the number of a work order could be written under several names at one time. The supervisor might keep the actual work order forms to hand out when teams are ready for them. Technicians themselves might print each work order form from a CMMS computer when ready. Figure 6.26 would be applicable to maintenance environments where technicians work as individuals (or on stable teams) and where specific start times are important. Each technician has a column of mailboxes or slots where the supervisor inserts work orders for different times of exe-

	Adamsn	Barber	Capper	Glade	Hunter	Jensen	Johns	Jones
Fri								
Thu								
Wed								
Tue	19	16		29 36		15	27 28	35
Mon								

	Kingsly	Pattersn	Richdsn	Sanchez	Smith	Wilson	Young	
Fri								
Thu								
Wed								
Tue	17	16		31 30	25			
Mon								

FIGURE 6.25 Optional mailbox arrangement to distribute paper work orders to lead technicians.

cution. At the beginning of the shift, the supervisor changes the heading of the previous shift to the following day of the work week. For example, at the beginning of Monday, there are headings for Monday and Tuesday. At the beginning of Tuesday, the supervisor changes the Monday heading to read Wednesday.

One method is not advised for assigning or handing out work orders. Some supervisors take the entire backlog of work from the computer whether or not it has been planned or scheduled and immediately assign technician names. In this manner, supervisors distribute their entire backlogs within their crews giving everyone a share of the plant work orders. This procedure generates the problem of not having any schedule expectations. Everyone has an individual backlog to work. When they finish one task, they should move on to the next. However, a major point of planning and scheduling is setting schedule expectations. Supervisors that assign individuals unplanned or even unscheduled work orders lose these advantages. Moreover, a CMMS computer has worsened this problem. Assigning a technician a work order in parallel to the planning process many times may result in a technician printing out the work order before a plan is available. With a pure paper system, at least the work stays in the planning channel unavailable for the technician to work prematurely.

Monday

	Dave	Jan	Max	Rex
7-8	119	120	121	
8-9	123			122
9-10		124		
10-11	125	126		
11-12				
12-1			127	
1-2				
2-3		128		
3-4	129			130
4-5				
5-6				

Tuesday

	Dave	Jan	Max	Rex
7-8				
8-9				
9-10		131		
10-11				
11-12				
12-1				132
1-2				
2-3				
3-4				
4-5				
5-6				

FIGURE 6.26 Optional slotted board arrangement to distribute paper work orders to individuals for specific start times. The second day was still being established.

During Each Day

Daily scheduling is a continual cycle. During each shift as technicians work jobs, the supervisor manages from the current day's schedule and creates the next day's schedule. As technicians finish jobs, they return the work orders to the supervisor who in turn takes the work permits back to operations so operations can begin to put the equipment back into service.

Even if there are no special testing needs, the technicians and supervisors must not wait until the end of the shift to turn in work orders and return work permits. Informing the operations group promptly upon completion of individual work orders allows more time to return equipment to service and restore plant capacity. Operators can operate the equipment sooner after completion of maintenance. If initial operation reveals problems or concerns, technicians are then also still on shift to return to jobs and make corrections or advise. Were maintenance to wait until shift end to return all completed jobs, operators would also not be able to unclear all the jobs at once. Allowing operators to work throughout the shift restoring equipment to service levelizes the operations group's efforts.

In addition to coordinating with the operations group, some jobs naturally run over or under estimated times. The supervisor ensures that the technicians give feedback to help the planners estimate future jobs and the supervisor adjusts the daily schedules for today and tomorrow as needed. Other situations may arise and cause the supervisor to adjust the schedules, such as plant emergencies or unexpected meetings.

Daily scheduling is not simply a form filled out at the end of the day for the next day's activities. Even more important, it is not simply handing out work orders at the start of the shift. Throughout each day, crew supervisors use the daily schedules as a tool to control work.

OUTAGE SCHEDULING

Although routine maintenance provides the greatest opportunity for improvement and so is the focus of this book, this section gives the associated keys to understanding the concepts of outage scheduling.

The vast majority of plant work orders are tasks for the standing work force. The standing work force at the plant maintains the plant day in and day out continuously. Planning leverages that day-in and day-out maintenance work. Plants frequently overlook the opportunities within routine maintenance because outages receive so much attention. Managers view outages as extremely important. They see unscheduled outages as tragedies and extended outages as fiascoes. In fact, plants organize outage events so well that they efficiently accomplish large quantities of work leaving everyone impressed with how much work can be done. They often attribute this great amount of work to extra effort based on the obvious urgency of the situation. However, the success is also due to the organizing effort, primarily the advance allocation of a specific quantity of work to complete. Similarly, planning and scheduling for routine maintenance can help accomplish an amount of work that can equally impress plant management. Planning and allocating a week's goal of work to a crew not only creates the same sense of urgency as for an "important" outage, but provides tools to manage and improve upon past problems. Nonetheless, it is worth discussing two keys to outage scheduling. First, planning provides accurate time estimates for larger jobs because larger jobs consist of a multitude of small jobs. Second, the scope of the outage must be controlled by managing the identification and inclusion of the small jobs.

An outage is normally considered the taking of an entire unit out of service. An outage is not simply shutting down a redundant process line or piece of equipment. Technicians many times can perform maintenance without taking any equipment out of service. Sometimes, technicians require taking only certain equipment or areas of a process out of service for only a brief period in such a manner that allows the unit to continue producing product. For example, operators might briefly take makeup water equipment out of service provided the plant has reserve tanks of water available. On the other hand, technicians cannot perform some maintenance tasks without causing the plant to make some or all of a unit unavailable for service. Maintenance may be able to complete some work while the plant runs at a reduced capability. For example, technicians may be able to work on one of two boiler feed pumps while a unit runs at half load. Maintenance situations may require shutting down an entire unit, require no shutdowns at all, or require varying in between unit conditions. Even with a requirement to be off-line, many plants can shut down an entire unit with hardly any advance notice or appreciable problems, operational or economical. Perhaps the company has not sold out its product line leaving open time. Perhaps technicians can complete maintenance during one shift and the unit can operate another shift during the same day. Plants normally call the taking of an entire unit out of service an outage. Outages may be major outages scheduled every so many years to overhaul major pieces of equipment on a routine basis or they may be short outages, either scheduled or unscheduled.

Some persons also call major outages overhauls or turnarounds. Major outages are when a plant schedules one or more major process systems for extensive routine replacement, refurbishment, or other maintenance. The work requires shutting down the entire unit.

These maintenance activities cannot be accomplished when the unit is operating and are often too large in scope to be done during shorter outages whether scheduled or unexpected. Many companies utilize set schedules for these events such as once every 5 years. However, the advent of predictive maintenance programs many times allows systems to run longer. Plants can then schedule major outages when sophisticated inspection methods predict the process system equipment needs attention.

On the other hand, a short outage is an event between major outages requiring taking the entire unit out of service. Short outages may be unscheduled, such as the sudden requirement to repair a burst boiler tube. The unit cannot run with the boiler tube losing process water, so the plant must take the unit out of service almost immediately or within the next few days. The plant strategy may also be to schedule short outages to take a unit out of service to perform maintenance tasks that do not require immediate attention. The plant performs these tasks in anticipation that they will lessen the likelihood of later unscheduled or surprise outages.

An evolution in the timing of short outages takes place as a plant increases its reliability through proper maintenance. A plant with fairly poor reliability usually has something break just when the plant otherwise needs a short outage. A number of work orders sit in the outage backlog. Yet rather than plan for a time to bring the unit off-line, the maintenance group knows the unit will "trip" or otherwise require shutting down for some unforeseen need on a regular basis. Take the example of a steam plant with poor water chemistry control. Boiler tubes burst periodically requiring shut down for repair. When a tube bursts with an estimate of, say, 12 hours to repair, the maintenance group springs into action also working the other outage jobs. The crew starts all jobs in the outage file with estimates of 12 hours or less. The crew may start longer jobs if the unit is not again needed immediately or management desires the unit to return in as good a shape as possible. Longer jobs that management decides not to start would wait for a future outage.

As a plant evolves from total reactive maintenance to more proactive maintenance, short notice outages begin to become less frequent. As fewer unscheduled, short notice outages appear, plant reliability improves. Yet the outage backlog first increases in size because fewer outages naturally occur. As plant reliability improves, the plant finds fewer opportunities to execute waiting outage work orders. Then the plant experiences some short notice outages occurring for new reasons. Previously, the maintenance group would have taken care of certain situations before they became too serious by doing some work during a short outage. However, when no outages come up, these situations worsen and themselves bring the unit off-line. For example, if technicians always repacked certain valves during outages, frequent unscheduled outages were available for this work. As reliability of the rest of the unit rises, the valves themselves begin to cause outages because the unit cannot wait. The evolution of the maintenance department's effectiveness continues until there is a predictability that the unit should be brought down for maintenance. At this point, management commitment for continuous reliability brings the operations and the maintenance groups together to schedule short, regular outages for routine maintenance in addition to the standard, infrequent major outages. The entire plant including operations and maintenance must adapt to a strategy of planned short outages to execute SNOW (short notice outage work). The plant must accept scheduling an outage in advance when there are a number of serious work orders on the SNOW list or there is a sufficient amount of SNOW work. The timely execution of the outage work prevents unscheduled outages. Overall plant reliability and availability increase through the strategy of short scheduled outages reducing the occurrence of infrequent, but serious, unscheduled ones. The evolution continues as maintenance and plant engineering perform defect elimination work to identify and replace equipment that requires excessive routine downtime. Moreover, maintenance, plant engineering, and the corporate project group perform defect elimination work to install plants or systems that incorporate lessons from the past. The evolution results in a superior performing plant capable of full capacity as needed and having minimal outage requirements for maintenance.

The evolution of the maintenance department's effectiveness changes with how it approaches short outages. As a plant rises from routinely having poor reliability to become a superior performing plant, fewer unscheduled outages become available for work. Therefore, regular, scheduled, short outages become more frequent.

Planning Work Orders for Outages

Many plants have work orders that they can only execute during an outage. To help the scheduler quickly select the outage jobs, the plant keeps a SNOW list or SNOW grouping of work orders. The SNOW list or grouping identifies or even keeps together the work orders that must be done on an outage, but not necessarily the next major outage.

There are only a few differences between planning work orders for short outages and for routine maintenance. Because technicians have limited time during the actual outage to gather parts and information, the company puts more emphasis on planners identifying and reserving anticipated parts. The planner has time to do this for even reactive jobs when an outage has not yet started. On the other hand, planners place a high priority on quickly planning outage work orders. They never know when an unexpected outage may suddenly occur requiring finished plans.

Individual work orders may make up some of the work for major outages, but not necessarily all. Large tasks such as certain turbine work may instead involve special outage books of notes from previous outages. The planners should take advantage of requesting help from the specific supervisors and technicians that worked particular areas of previous major outages to determine estimated times and labor requirements. The outage books should also identify parts and tools from previous outages.

Key Concepts in Scheduling for Outages

Many individual work orders of jobs make up outage work. Therefore, the scheduler can utilize the concepts of advance scheduling developed for routine, weekly scheduling. This allows the scheduler to make accurate enough assessments of time frames for the large quantities of work involved in outages. This concept provides the first key to understanding outage scheduling.

Because outages consist of many individual jobs, the scheduler can apply the concepts that make weekly work allocations an accurate tool. A scheduler can use planned work order estimates to determine accurately the duration and labor hours for major outages. In a routine week of maintenance, a scheduler can allocate the right amount of work even though the time estimates for small jobs have a tremendous amount of variance in individual accuracy. For example, the planner's estimate for replacing a single control valve may vary considerably. Yet a weekly schedule allocation of 100 jobs smoothes out any variations of individual jobs. The work force might therefore have confidence that it could accomplish the overall amount of work in the scheduled week. The scheduler may similarly consider a single large job to consist of many small work orders and therefore accurately estimate labor requirements for the large job. The scheduler and planners together can therefore estimate the total duration and labor requirements of overhauling 20 control valves with a satisfactory degree of precision. A major outage consists of many large jobs and the handling of each large job can be approximated to the weekly scheduling process. Consider the major overhaul of a large steam turbine consisting of many individual tasks on many individual systems. The scheduler and planners together can reasonably estimate the total duration and labor requirements of restoring the turbine itself. The restoration involves many small tasks such as disassembly, inspection, lifting, transporting, machining, coating, polishing, transporting, lifting, assembly, fastening, and alignment. There is also a myriad of miscellaneous work orders that the plant identified over the past few years that could only be done during the overhaul. The planners have already planned these work orders. The scheduler can group them to determine their group labor requirements. Overall, the scheduler uses the concept of the grouping of small tasks allowing overall estimate accuracy.

Note that during routine maintenance, the crew forecast of labor available for a single week determines how much planned work the scheduler assigns. For a major outage, the amount of work is the dependent variable. That means the amount of work determines the length of the outage considering basically a set amount of labor each week. After determining the initial estimate of the outage duration, management can evaluate options to increase the work force. Management may supplement the regular labor force using 24-hour, around-the-clock work shifts or contract labor. Many plants have labor sharing agreements to help each other during major outages. For outage maintenance, the scheduler adjusts the outage time to match a given amount of work, then considers special labor arrangements. For nonoutage, routine maintenance, the scheduler adjusts the amount of work to match a given amount of labor hours.

The overall outage can be managed through CPM's and other special scheduling techniques. However, these techniques show the large groupings, not the minute, individual maintenance tasks. That is why these techniques can be successfully used with the outage.

Because a major outage consists of many individual jobs, the crew supervisor must create daily or shift schedules as the outage proceeds. A scheduler can set the major activities and overall times for the outage, but cannot control individual jobs. At the beginning of each shift, the crew supervisor must ensure persons understand their assignments based on the progress of the previous shift. The supervisor must provide this coordination during a major outage even though technicians usually stay on the same equipment and do not move around too much between different areas. An entirely different group of technicians may have worked the previous shift. In addition, the technicians may be executing work that the plant performs only once every 5 or 10 years. That means the average technicians may have drastically limited experience with the work over their entire employment at the plant. On the other hand, the often older crew supervisor may have critical personal experience.

The scheduler gathers appropriate SNOW work orders and sets the labor requirements and duration for a short, scheduled outage in a similar manner to a major outage. The scheduler and management determine the best crew and time arrangements considering labor availability and shift options.

A single event often drives a short outage. Consider first an unscheduled short outage. Consider again the boiler tube that erupts and causes a unit outage. Maintenance must repair the tube. This single task causes the unit to be on outage and unavailable. For such a task, the pertinent crew supervisor and management estimate the duration of the outage, say 18 hours. The scheduler then takes all of the work orders that have been waiting for an outage and selects the ones that can be done in 18 hours or less. Maintenance crews then complete as many of the jobs as possible. So for a short, unscheduled outage, the primary job sets the time frame. Labor availability determines how many jobs the crews can accomplish. The scheduling consists of the scheduler or supervisor taking all the outage backlog jobs with an estimated duration within that time frame and then considering the persons needed to work the jobs. If there are any backlog jobs that have not yet received planning, the supervisor guesses the time requirements and includes suitable ones in the outage scope. The supervisor writes down all the jobs on a daily schedule sheet with hours for each of the crew members. This is very similar to the regular weekly and daily scheduling routine except for one difference. The amount of hours the crew has for the week does not drive the schedule, the outage backlog selected from the outage file by duration does. The supervisor reassigns persons from their nonoutage tasks currently under way and plans overtime as needed to get the work done.

The second key in outage scheduling is that the scope of the outage must be controlled. If the scheduler has a specific amount of work, the scheduler can develop specific time schedules and labor requirements. If the company allows the amount of work to vary, the time schedules and labor requirements cannot help varying as well. Although the techniques of accurate scheduling are important, the overwhelming key ingredient in making an outage go well is agreement on the scope. The scope itself is less important than agreement on the scope. Many times an outage will start with one scope of work, but as soon as the plant takes the unit off-line, the scope doubles.

This is a simple concept to apply to an outage consisting of 100 work orders. The scheduler can reasonably set the labor time requirements from reviewing the job plans. Then the scheduler can establish the overall schedule based upon management preference of crew shifts. However, suppose the amount of outage work orders suddenly jumps to 150. The scope of the outage has changed. It has increased by the 50 new work orders. The scheduler must change the schedule.

This consideration is especially important for major outages where the initial part of the outage may consist of inspections of major machinery. If the inspections reveal more serious damage than anticipated, the sudden inclusion of more work may extend the entire outage. This is through no fault of the scheduler. After the inspections determine the extra work, the scheduler must then analyze options of labor or critical path changes for management review. This is why outages including major inspections are difficult to schedule precisely. The advent of predictive maintenance technologies has greatly assisted scheduling for major outages. Through sophisticated technology, PdM allows more precise determination of maintenance needs before the plant shuts down major machinery to begin outages.

Knowledge of the scope of work provides only part of this second key to outage scheduling. The rest comes from understanding that the scope must be controlled. The plant must identify work as far as possible in advance. The plant must not include new work on the eve of or even during the outage whenever possible. Late announcements of work destroy schedules and labor arrangements. Late inclusion of work causes that work to be poorly planned. The ensuing confusion may also cause incomplete execution of new work hastily identified. It might also contribute to hasty decisions to delete other work from the schedule. The company may have already used the set schedule to make arrangements for production and sale of product which may become expensive to change. Additional labor necessary to maintain a set schedule with an increased scope may be more expensive or less qualified than could have otherwise been arranged. Finally, there may be insufficient advance lead time to procure material necessary to execute the work. The maintenance group would not be able to execute that work.

To reduce these changing scope problems, the scheduler first begins identification of future outages as far as possible in advance. Many companies have 1-, 5-, and 10-year outage plans. These plans give approximate periods of all anticipated outages. The 1-year plan might set specific days or weeks, whereas the 10-year plan may set specific months or seasons. As the outage time approaches, management allocates preparation time for the schedulers and key company personnel to begin defining the work scope and time frames. The particular scheduling horizons depend on the specific type of outage, equipment lead times, and labor resources. Most of the scope definition work for a larger outage is straightforward 6 months to 1 year before the scheduled outage starts. The initial project team makes use of outage files and books. Even work completed every 5 or more years is still repetitious work. Crews executing outage work must record feedback to make files most useful. The period of about 3 months before an outage starts is when scope additions multiply if left unattended. During these 3 months, it seems almost everyone knows about new work requirements. However, with less than 3 months before the outage, there may not be enough material lead time or other time to prepare adequately for the new work. Therefore, the scheduler must pay close attention to the control of the outage scope.

Schedulers commonly control the scope of outages through the use of lists. The scheduler may issue a list of known work with a stated main purpose for the outage 6 months to a year before the start date. The scheduler has an initial meeting with supervisors to identify maintenance needs. Then, with increasing frequency until the start of the outage, the scheduler continues to meet with the supervisors and issue lists of identified work. Planners or special outage planners finish planning the identified work tasks as necessary to have them ready to execute during the outage. An outage project manager ensures this cycle of publish, identify, and plan continues up to the start of the outage. Management support and organizational discipline help ensure giving serious attention to timely identification of work. Management should not appreciate late identification of outage tasks. If managers do not wish to have an unexpected outage extension, they must be willing to freeze the outage scope and not allow routine additions at some point before the outage begins. The scheduler might issue a statement at some point before the outage that "Any work identified after this week must be arranged and managed by the originator of the work." The early start of giving attention and listing the work greatly reduces the occurrence of later scope additions.

During the course of an outage, the scheduler continues to meet with the crew supervisors to identify completed work. The scheduler also continues to publish lists of work remaining. The scheduler compares actual completion of blocks of work against expected completion to measure the progress of the outage. In order to encourage supervisors to attend meetings during the execution of the outage, the scheduler should limit the meetings to only 15 or 20 minutes.

After the outage is over, the scheduler should still schedule one or two meetings with the crew supervisors, planners, and other personnel, possibly even including technicians. Just as a planner needs feedback to improve future plans, the scheduler and planners seek information to improve future outages. The final meetings should address what went right as well as identify where the team could make improvements. These meetings should occur soon after the outages before personnel forget information and ideas.

The plant handles scheduled short outages very similarly to major outages in regard to work scope. Smaller outages that the plant determines are necessary only months, weeks, or days before starting, and have similar but less extended preparations made. The operations and maintenance groups together arrange to have a short outage at a future scheduled time to maintain the plant's capability of operating at full capacity. This is not a recovery from a trip or loss of capacity. The key to how much work the maintenance group will accomplish for a short scheduled outage is the plant decision on the scope of work. The scheduler must continually encourage the routine identification of work even if the work can only be done during an outage. This ensures the backlog contains the necessary work orders for an outage before the last moment. The scheduler assesses what routine preventive maintenance to include. The scheduler reviews any predictive maintenance recommendations or other corrective maintenance in the backlog. With this information, the scheduler prepares a preliminary scope of all jobs to include in the outage for review by the maintenance crew supervisors and plant management. The scheduler takes the scope of work and then assesses how long the outage should last based on discussions with crew supervisors for crew availability and management preferences for off shift and overtime work. The crew supervisors create a daily scheduling sheet(s) for the outage to get all the work done.

As previously discussed for unscheduled short outages or trips, the primary failure is often the item that determines the length of the outage. The scope normally consists of all SNOW work orders that the planners estimate have a duration of equal length or shorter.

Management must be willing to set a freeze on the scope of even short outages. It must resist the addition of new work after an unscheduled short outage begins or after setting the scope of a scheduled outage. Otherwise, management must accept the responsibility for outage schedule changes.

A final necessary note includes the involvement of the operations group. Timing governs the success of outage work in such a way that one must not forget the time involved for operator tasks. Operators must not only clear equipment, but return equipment to service. Managers and schedulers must include the operations group in all outage meetings to discuss clearance and restoration to service of individual components as well as overall unit shakedown. Operators may have a preference for the timing of the return of specific components to levelize their activities. Their knowledge may also profoundly affect the overall scheduling of the outage. For instance, a major steam plant may sometimes require days or weeks to clean boiler water to allow return to full capacity. As with any maintenance work, the maintenance technicians are responsible for delivering equipment that is ready to run. However, the operators have the responsibility of testing and returning the equipment to service. Schedulers must include the operators when considering maintenance work.

Two key concepts help the understanding of the scheduling of outages. The first key is realizing that the scheduler can only have great accuracy when scheduling *blocks* of work orders. Grouping of many tasks into blocks of work for an outage tends to smooth out the inaccuracies inherent in the estimates of individual tasks. The second key is realizing that the overall ability of being able to schedule outage work accurately lies in the control of additional work to the original outage scope. Schedules or resources must change if the work scope changes. A scheduler can schedule the work scope of an outage. The plant must control the scope.

QUOTAS, BENCHMARKS, AND STANDARDS ADDRESSED

The terms quota, benchmark, and standard see frequent usage in maintenance and should be addressed in light of the current scheduling context. The normal concepts implied by these words do not lend themselves very well to a planning and scheduling operation.

Quotas establish amounts of work that a crew must do. For example, management might dictate that a certain maintenance crew must always complete 60 work orders every week. At first glance, the development of a planning and scheduling system seems to have that very thing in mind. However, a quota is more of a mandatory figure that does not allow very well for consideration of current events, quality, or actual jobs ever being different from the plans. Quotas do not provide the answer to superior maintenance. Rather, proper planning and scheduling set schedule expectations and realistic goals based on current conditions as well as provide the means to improve upon past jobs. A technician must be able to point out why a job should be extended in the case of special circumstances. There may be valid schedule pressures and there may be times a technician cannot be the sole judge to delay a job. However, these factors must be maturely worked out for the optimum benefit for the plant as a whole. Rather than setting a strict quota of work orders to complete, management should consider how many technician work hours the crew has available and assist the crew to select that same amount of estimated work hours of backlogged jobs that would most benefit the plant. To emphasize that a planning and scheduling operation does not promote quotas, consider the following. If it is not a quota to assign two persons to a job, why would it be a quota to assign 2 hours to a job or two jobs to a person?

Compensation arrangements that take into account production amount without regard for quality form a type of quota. Management should avoid these situations or watch them very closely. For example, wages based on number of jobs or number of "book hours" might encourage a technician to pay insufficient attention to quality. It is true that the supervisor has less need to motivate such piece workers; but are they performing proper work? Instead, paying technicians by the hour, but giving them sufficient amounts of work to do requires more supervisor effort, but appears to keep quality higher in focus.

Benchmarks are self comparisons to how other facilities perform in certain areas in which one has an interest to improve. For example, management may compare how much it spends yearly on maintenance versus the most profitable companies in similar or dissimilar industries. The comparisons may let management know if its own maintenance department is relatively effective. However, a comparison itself may not tell management how its own company can improve. The other facilities may have certain factors that provide for their particular success. Simple benchmark comparisons do not readily reveal these factors. The other facilities must be carefully studied for benchmarking exercises to become most useful. How similar is the other facility? Perhaps the other plant has a greater abundance of skilled labor available. Perhaps the other plant has already made the transition from reactive to proactive maintenance. Perhaps the other company invests regularly to replace troublesome equipment. Perhaps the company has an active program for maintenance personnel input into new plants being built. The point is that simple benchmark numbers may not tell why plants perform differently. There are often key factors that must be understood beyond the benchmark number. So it is with planning and scheduling. A benchmark comparison that shows a plant has a planning department and schedules its maintenance does not tell if or why those programs are beneficial. A benchmark telling that wrench time is different does not tell why it is different. The planning and scheduling principles in Chaps. 2 and 3 embody obvious factors that influence how well planning and scheduling work. In addition, the entirety of Chap. 1 points to other factors necessary for planning to function. A simple benchmark would be difficult to use among different plants in many of these regards. Consequently, benchmarking among plants to control a planning operation may not be as beneficial as closely adhering to the planning and scheduling principles and other guidelines presented in this book. Nevertheless, the principle underlying benchmarking—to visit other plants to pick up good ideas—may invaluably assist to improve any aspect of plant operation and maintenance. Benchmarkers should try to visit best performers. They should attempt to understand how, not just how much.

Another use of the word benchmark implies less of a cross-company comparison and more of a simple goal or idea of what one's performance should be. The planner's estimate of a job's labor hours do set somewhat of a benchmark in this regard for the technician's consideration.

Standards present a combination of quotas and benchmarks, but on an individual job level. A real standard applied to a specific job would dictate beyond any doubt how long a job should take. One way an engineer or analyst would establish a standard would be to study a task as it is repeated many times by different technicians. The analyst or engineer together with some of the technicians might then decide the best way to perform the work. Then technicians trained to perform the work in this best manner would be timed. The resulting labor hours and duration would become the official job standard. This approach may be practical for an automobile repair shop where industrial engineers have studied specific tasks repeatable on identical vehicles maintained in similar shops. This approach is less applicable to an industrial plant where technicians may repeat specific jobs only once or twice over the course of a year. There is limited opportunity to observe and study such work. The manufacturers may have some ability to specify standard maintenance tasks for their equipment. On the other hand, manufacturers may be better qualified in the manufacture of the equipment rather than in its maintenance. In addition, the great diversity in the shop arrangement and personnel skills of the persons using the equipment may make generic standards useful for a starting point, if practical at all. Preventive maintenance tasks may lend themselves to locally developed standards because technicians may execute them on a more frequent basis than once or twice a year. Nonetheless, the great productivity improvement available through planning and scheduling comes from having some schedule control, not necessarily incredibly precise estimate accuracy. Typically, the introduction of proper planning and scheduling in a maintenance organization dramatically improves productivity. Addition of precise job standards contributes a relatively smaller productivity gain. Normal job planning simply does not study jobs thoroughly enough to set precise time estimates. The planned estimates are accurate enough for scheduling work, but not for establishing official job standards. Fortunately, the ability to schedule the work in a reasonable fashion is all that is necessary.

Nonetheless, when used less formally, the term standard is somewhat applicable to the planner's estimate of a job's labor hours. The planner's estimates are said to be the job standard. One must keep in mind, however, that these are not engineered standards. They are simple, initial determinations of a skilled planner.

Setting estimates and assigning work through planning and scheduling does not necessarily involve engineered standards, production quotas, and cross-company benchmarks.

SUMMARY

This chapter described the specific activities that accomplish weekly and daily scheduling. For advance scheduling, a scheduler simply allocates an amount of work orders for a week. The scheduler does not set specific days or times to begin or complete each work order. The scheduler works with the crew supervisors to establish forecasted labor hours and then selects that quantity of work order hours for the allocation. Specific methods, routines, and forms help the scheduler select the best mix of work for the plant. For daily scheduling, the crew supervisor selects work orders mostly from the weekly allocation. However, the supervisor also maintains the flexibility to reassign the crew for emergency and other urgent work that may arise. The supervisor may follow different methods and procedures to select and assign the appropriate work each day. All of these methods and procedures have certain elements in common, primarily giving each crew member a full shift of work based on planner job estimates. As plants gain experience with planning and scheduling, staging certain job items may further improve labor productivity. These techniques of scheduling greatly assist maintenance in improving its labor productivity. This chapter described the exact steps of scheduling to clarify the concepts of scheduling. After understanding the concepts, readers may implement alternative steps than the ones prescribed. This chapter should allow companies to implement their own effective scheduling.

Routine day-to-day maintenance offers the greatest opportunity for planning and scheduling to make a difference. On the other hand, companies typically execute maintenance outages with much success already. Consequently, this book does not dwell on the actual scheduling of outage maintenance. However, the scheduling of outage maintenance relies on particular concepts inherent in the practice of routine maintenance scheduling. One concept is the increased accuracy of time estimates achievable for blocks of work made up of smaller jobs with less precise time estimates. Another concept is the control of inclusion of the smaller jobs that make up the larger blocks of outage work. If the scope of work continually changes for an outage, the overall outage schedule must change as well. The chapter addresses these concepts as keys to outage scheduling in addition to describing the routine scheduling of maintenance work.

CHAPTER 8
THE COMPUTER IN MAINTENANCE

Some persons think that planning work orders consists of handling parts and tools before jobs start. Other persons think that it consists of developing detailed procedures for jobs before they start. Still other persons think that it consists of utilizing a computer or CMMS (computerized maintenance management system). None of these concepts quite reaches the mark. The proceeding chapters have set forth maintenance planning as a process, one that gives maintenance managers an increase in productivity. The process gives technicians a boost on the learning curve from past jobs. The process also gives supervisors job scopes and time estimates allowing them to assign sufficient daily work toward weekly work goals.

Nevertheless, more than a few persons describe their maintenance planning function by how well their CMMS works. Many of these persons profess that "everything will be perfect" when they fully implement their CMMS. Similarly, many persons wonder why planning "does not quite seem to be working" even though they have installed an expensive CMMS. Unfortunately, planning is not simply using a computer, and just because a company has a computer does not mean it even has a planning function. The CMMS can be a tremendous resource for planning, but it is not planning itself.

Perhaps unreasonable expectations contribute to disappointment for many purchasers of maintenance computer systems. Larry Beck (1996) relates survey results of manufacturing executives that indicate they typically require minimal cost justification before implementing such systems. Many of these executives expect productivity gains, but may not have specific reasons why the CMMS should deliver such improvements. David Berger (1997) says that the failure rate of CMMS package implementation is commonly thought to be about 50%, depending on one's definition of failure. Christer Idhammar (1998) places the success rate for CMMS packages at only 18%.

Companies must look at computer systems as simply another tool. They are certainly not the ultimate remedy to one's maintenance troubles nor the ultimate solution to provide improvement. Nevertheless, a CMMS is an important tool, an information tool. Moreover, a CMMS is not a tool for just the maintenance force; it is a tool for the entire plant or company. Many companies call their computer system an asset management system rather than a maintenance management system. The system helps with information for more than just the maintenance staff. In addition, the term maintenance has a bad connotation from the prevalent culture that thinks of maintenance as merely repair of broken equipment. With regard to maintenance, this information tool is one key to further improvement after the basic processes are correctly in place. The CMMS does not provide a step improvement as does implementing the basic process of planning and scheduling, but the improvement is significant.

Planning is also a tool, not the ultimate maintenance solution. The CMMS extends beyond planning, and even maintenance itself. However, the planning system also extends beyond the

CMMS. Examine the six planning principles against this information tool. The CMMS does not dictate that planners should be separate from crews. It does not dictate that planners should concentrate on future work. The CMMS does require component level equipment designations for recording information. The CMMS does not emphasize the technical skill of the planner in setting scopes and estimates. The CMMS also may not count on craft skills. The CMMS certainly cannot measure wrench time as only statistical work sampling is adequate. On the other hand, one goal of the CMMS is the same as the planning system, to help reduce delays. Examine the six scheduling principles against the CMMS. The CMMS does not dictate that plans should be made for the lowest possible skill level. The CMMS may presume that priorities and schedules are important, but may not dictate that schedules should not be interrupted nor enforce organizational discipline against setting false priorities. The CMMS does become involved in forecasting availability of personnel. The CMMS may allow sensitivity to examine scheduling work hours for 80%, 100%, or 120% of a crew's available hours. On the other hand, the CMMS would not dictate the principle of 100% as a weekly goal. Neither would it normally dictate the principle of working persons below their skill levels to match job hours to crafts available. Instead, the CMMS may blend the weekly and daily scheduling routines into setting weekly schedules on a daily basis by the computer operator who is a planner, scheduler, or crew supervisor. The CMMS may help measure schedule compliance, but it could not on its own first define what activity would constitute compliance. Finally, the CMMS may not differentiate planning's different responses to different degrees of job reactiveness. One sees the principles that embody a successful planning program do not come from the CMMS. To a large extent, a CMMS is a database manager where planning may seek information. The CMMS contains information; it should not dictate planning strategy.

Regardless of planning not being synonymous with a CMMS, planners are the major users of such a system when in place. A CMMS soon becomes one of their most valuable tools. In this perspective, a chapter on the computer's role in maintenance is most justified. This chapter cannot be all inclusive of the role a CMMS would play in an entire maintenance organization or plant because this book is about maintenance planning. The influence of a CMMS extends beyond maintenance planning. Nonetheless, the involvement of planning with a CMMS must be addressed.

In the context of maintenance planning, the computer helps in two ways. First, it automates and facilitates existing processes to improve efficiency. Second, the computer can add value to produce benefits otherwise not practically achievable. On the other hand, the computer may not affect certain maintenance functions at all or it may add complications to certain functions in the maintenance process.

The previous chapters of this book establish specific strategies and techniques of planning. In this context, the following sections address computerized maintenance management systems. The first section covers what is meant by computerization. The next section addresses the relative value of computerizing different areas of maintenance. Then the use of templates or "canned" maintenance solutions is covered. The logistics of becoming involved with a CMMS and having a user friendly system is discussed. The last section provides suggested CMMS features applicable to this book's philosophy of planning. These sections also make reference to App. L, which gives examples of several of the points of discussion.

TYPE OF COMPUTERIZATION

To establish a framework for discussion, it is helpful to review the basics. There are two major issues with a number of associated minor issues. The two major issues are what type of computer system is involved and who creates the software.

There exist a wide variety of types of computer systems. The first computers were mainframes, and many company software applications today still operate on them. Mainframe computers themselves are expensive, as are the in-house information systems (IS) groups staffed to develop and maintain the software for them. Some mainframe maintenance applications are fairly sophisticated and helpful. However, in-house information systems groups usually prioritize the handling of basic company applications such as payroll, human resource systems, and general ledger accounting ahead of computerization of maintenance functions. Many organizations with only mainframe computer capability do not have much of a maintenance computer system. These maintenance groups may have certain codes tied into the payroll system and can use this limited information for certain analysis. With the advent of personal computers, many maintenance groups began to use maintenance applications on individual computers not tied into any company-wide systems. A single individual that operates the CMMS for everyone keys individual computer applications. With networked personal computers, maintenance applications allow more than a single person to review or manipulate information. Networks may be LAN (local area networks) at the single plant site, or WAN (wide area networks) covering multiple facilities over a large geographic area. Many companies are transferring their software away from mainframes to networked computers using client-server structures. With the evolution of more powerful personal computers and networks, client-server structures allow large databases and programs to interact from central computers with local computers. Small systems run from individual personal computers and simple networks may not need IS support. More complex networks and client server applications require IS support.

The developers of maintenance software may be in-house personnel or vendors. The advantage of using in-house personnel is having control over the customization of the system. Unfortunately, as mentioned above, in-house IS personnel may give maintenance work less attention than desired. In addition, in-house IS and maintenance personnel even working together may not possess as much knowledge or skill as could be obtained commercially. Then, once IS writes a program, it may have limited resources to upgrade the software continually to take advantage of new computer technology or maintenance practices. CMMS vendors are usually in a position to incorporate the most successful maintenance practices across a number of companies and even industries. The market also drives CMMS vendors to keep up to date with computer technology. Theoretically, instead of a small, in-house IS staff developing software for a single maintenance group, a CMMS vendor can maintain a large staff developing the best software and sharing the cost over many maintenance groups. Moreover, the CMMS vendor specializes in the software, whereas it may not be a central concern to an in-house staff. Finally, an in-house staff generally appoints a single individual to the maintenance of maintenance software. If this individual was the developer and left employment at the company, the maintenance group may suffer due to few persons being able to pick up the software issues. Contrary to this situation, if the in-house individual left a vendor-supplied CMMS, the CMMS vendor would be able to provide assistance for continuity.

The conventional wisdom in the maintenance industry appears to be working with the IS group and selecting a vendor CMMS that closely mirrors one's current maintenance process. A company would pay the vendor to provide some initial customization. Then, ongoing management of the software would be by maintenance fee with the vendor with in-house personnel performing some ongoing customization. Under no circumstances would the in-house group receive the source code from the vendor and make modifications that might render the system unrecognizable to the vendor's specialists. What a maintenance group desires is a system that automates how it currently conducts maintenance. The maintenance group also desires some value added functionality that allows accomplishing certain tasks not practical without a computer. It does not want to procure a CMMS in the hope that the computer will teach it how to conduct maintenance properly. If a company does not already have a good maintenance process, it should wait to computerize.

In contrast or opposition, the maintenance planning group may benefit from computerization without buying a CMMS. All planners should have access to the Internet and email. One mechanical maintenance planner helped an electrician find an exact procedure for replacing a faulty device manufactured by a company that had been out of business for over 10 years. The planner searched the Internet and had a vendor email him an exact replacement procedure within a half hour of looking. Finding information and parts and even purchasing items on the Internet may boost a maintenance organization. Searching for MSDS information may be practical although legal requirements may dictate having on-site records. Other computer programs without a CMMS may help maintenance. A simple database program may adequately store nameplate equipment information. A clerk may easily be able to type and print work orders for PM's with a simple spreadsheet and word processor. A company should not purchase an entire CMMS with the sole benefits expected to be the automatic printing of work orders and the replacement of a single clerk.

BENEFITS WITH THE CMMS

Arguably, these are the benefits of having a computer system mostly from a maintenance planning perspective.

Computerizing the inventory system produces the overwhelming largest value added benefit. Knowing part availability and allowing economic order quantities to maintain part availability give a major financial saving. It is not unheard of that computerizing inventory might reduce a $5 million inventory level to $1 million in a single year. The company savings from inventory alone justifies the purchase of a CMMS. On the other hand, many company storerooms have already computerized their operations with inventory-only software without the purchase of a CMMS. The value of the benefit of converting an existing computer inventory system to one contained in a CMMS package is less significant. Nonetheless, many computerized storerooms utilize mainframe systems and must convert to nonmainframe systems for financial reasons. Early involvement of maintenance management with storeroom management may help the company make a strategic decision to procure a CMMS for everyone to utilize. Regardless of whether the inventory system is standalone or part of a CMMS, planners should be able to locate and reserve parts for specific work orders.

Simply providing easily obtainable reports gives the maintenance group its second largest benefit from a CMMS. This is another value added opportunity and not merely an automation of an existing process. Management and others need information to work within and improve a maintenance organization. A CMMS provides valuable information often not otherwise available. How much did a particular piece of equipment cost the company over the last 5 years? What are the most costly systems in terms of maintenance expenditures? What is the current backlog of work orders? What is the current backlog of work waiting on parts? What is the current backlog of work for electricians in terms of work hours? What work orders caused lost availability over the last week? Is this trend rising? What work orders could be worked tonight if there was a short notice outage? What is the trend in percentage of reactive versus proactive work orders over the last 2 years? How much have failure and breakdown work orders been reduced? Which crew has the greatest amount of failures occurring in the systems it maintains? Which work orders are waiting for planning? Which work orders have been completed, but not closed because of drawing revisions needed? Are there any planned work orders that can be worked along with the emergency job just started in this system? How many hours are spent for PM? How many hours are spent for corrective maintenance that is generated from PM work? Just knowing that there are 651 open reactive work orders may cause management to take more decisive action than a previous feeling that the backlog was around 50 work orders. As one can see, management can determine the degree of success of the maintenance program's efforts with information readily available from a CMMS. To make the CMMS information usable requires effort on the part of the planning organization. The planners normally code work orders to allow future reporting or analysis. Codes such as type of outage required, type of work, and equipment system are necessary. The planners are the persons most familiar with the plant coding structure and provide consistency when they assign codes to new work orders each day. Whenever they handle them, planners should also scan work orders for "sense" and correct inaccurate information.

The next most valuable benefit of the CMMS is the finding of work orders. This includes work order loss prevention and determination of current work order status. It also includes sorting work orders, a benefit similar to the report benefits. First, the manual method of assigning paper work orders to crews involves a risk of lost work orders. If the physical piece of paper becomes misplaced, the work request might be forgotten. This might not appear to be a problem for the plant management used to thinking of maintenance assignments as missions to correct obviously failed equipment. How could these work assignments be forgotten? However, the maintenance group accomplishes its critical objective of preventing problems from happening in the first place through regular identification and correction of minor deficiencies. If one of these paper work orders becomes misplaced, its loss may go unnoticed until the minor deficiency becomes a glaring problem that maintenance could have avoided. A maintenance crew that normally focuses upon urgent work orders may tend to put off working less urgent work. Even a good filing system may occasionally lose paper work orders that maintenance does not immediately execute. The CMMS avoids this problem because the work order is not ever considered to be the physical document in the first place. A work order is literally what the term suggests, an order to do certain work. That identification of work resides in the computer as the actual work order. Anyone can run a report showing a listing of all work orders at any time. If a technician loses a printed out document describing the work, the computer still shows the work required. The technician or supervisor can print out another copy of the work description if desired at any time. This benefit does not require a CMMS and could be derived from a simple database of work orders recorded by a clerk each day. The management commitment required under such an arrangement would be the insistence that supervisors are responsible for the work on the database listing, not the physical documents they have in hand. In addition, if a paper work order is lost, someone would have to recreate the document from the database. These arrangements usually run into some difficulty with paper documents lost after work completion either in the field or the minifiles without the clerk registering their completion. Then, the database is obviously less current than the actual holding of paper work orders as an indication of work not completed. On the other hand, once the maintenance group adopts a more complete CMMS, supervisors seem to take better ownership of helping update work order status. The supervisors begin using the CMMS database to organize and manage their own work. Management's claim that the CMMS has the real work order and its status also appears more credible. The second part of this benefit is realized for the entire plant as the status of each work order on a CMMS begins to have real value. Before the CMMS utilization, the originator of a work order had few means of determining if the work requested had been done or would be done. If written a month before, the originator might well presume the maintenance group had put off the work order for the indefinite future. The work order had gone into the black hole. With most network CMMS packages, the originator can easily find the pertinent work order through a number of different search options. The originator might be able to hunt by work order number, originator name, date of approximate entry, equipment number, or any number of choice key words of problem description. After finding the right work order, the status of the work order is evident, whether waiting for approval, planning, scheduling, or closing of the paperwork. One major power station bought a sophisticated CMMS package for the sole reason of allowing operators to find work orders and their status. The planners, schedulers, and supervisors also use the CMMS package's ability to find work orders to sort out certain work orders. A planner might easily find all the new reactive work orders to plan for the day. A scheduler might sort all the work orders that have been planned in order of priority, system, and job size to facilitate scheduling work for a crew. A supervisor might sort out all the work orders already assigned and in progress as a listing to help manage the day's activities. Reports and better visibility of equipment work orders help the plant optimize equipment maintenance and capital investments timing as well as make better repair versus replace decisions. The ability of a CMMS to give a view of what is out there in real time is an important benefit.

A very closely related benefit to making reports available is the linking nature of the CMMS. The CMMS is an automation of the minifiles linking history, parts, procedures, safety data, tools, and other information directly to specific equipment. Operators can keep track of standard clearances. Maintenance personnel can keep track of warrantee and service agreements. Planners and engineers can keep track of cost. The CMMS connects all this different plant data to the equipment.

Beyond this joining benefit, the CMMS provides another plant advantage. In the past, different plant departments kept various independent records of important equipment information, many times duplicating the work of each other. For instance, three different groups might have a record of nameplate equipment data. One problem from this arrangement was when the maintenance or project group replaced the physical equipment. Not all of the plant departments might update their nameplate data. In time, the different departments ended up with conflicting information in their records. The advent of computerization made this problem of conflicting plant information worse. Personal computer spreadsheets and databases allowed easier organizing of data, and departments began to collect more information. A hodgepodge of plant data resources exists at many plants. The network CMMS provides a solution to this situation when everyone can access a common database for different types of equipment information. Authorized persons in each department can update a common database a single time with the latest information. The database should represent the latest information any of the departments possesses. Work order and equipment information can also be remotely viewed through the CMMS. Instead of journeying to the planning department to review minifile contents, engineers and others can find what they want on the computer. Instead of going to the engineering department to review equipment technical data, planners can find what they want on the computer. A plant should consider implementing a CMMS ahead of the proliferation of multiple databases around the plant if possible.

The CMMS provides another benefit to the planning department with regard to manipulating scheduling information. An advance schedule should normally be a simple allocation of work, and a daily schedule should involve the supervisors' personal knowledge of crew individuals for best work assignments. Nevertheless, a CMMS might facilitate some of these efforts. In addition, the CMMS allows easy "what if" reviews of different alternatives. The CMMS also allows easy publication of the schedule to anyone interested. This promotes better craft coordination as well as operations group equipment clearance arrangements.

Next, the CMMS helps the maintenance department by automating the PM generation of work orders. A small plant may avoid having a clerk to generate PM work orders manually from a master spreadsheet. The cost of having a clerk generate PM work orders manually may not be significant for a bigger plant. However, the volume of PM work orders for a bigger plant may be large enough to cause some concern over having them correctly issued and assigned. The CMMS precisely sets the PM work orders each time they are issued. Although these PM logistical advantages may seem slight, the importance of correct preventive maintenance to the maintenance group's mission is significant.

CAUTIONS WITH THE CMMS

Of course, the most obvious downside of computerizing is thinking that a computer will correct a faulty maintenance process or philosophy. Computerizing a poor maintenance process will not help maintenance. Karl Kapp's (1996) "USA" admonition must be heeded: "Understand, then Simplify, then Automate." The computer may create the illusion of progress and maintenance advancement when equipment performance has not improved. One must guard against the computer becoming a distraction to real maintenance improvement.

There are also other considerations to be made when computerizing. One of the foremost concerns is the reliability of the computer system which may be a function of the particular CMMS package, the plant computer equipment, or both. The more a plant counts on the CMMS to assist with daily maintenance functions, the more the CMMS has to be available. It is not acceptable for the computer system to crash routinely as planners and others utilize the CMMS to perform their jobs. If the operators write work orders in the middle of the night, the CMMS should routinely work in the middle of the night. If the planners report to work at 6:30 AM to code work orders, the CMMS should routinely begin work at 6:30 AM. The IS department must accept the same philosophy as the maintenance department that its job is to provide an operating machine, not provide a repair service when called.

On the other hand, the planners and the maintenance department should understand their jobs well enough to be able to carry on in the sudden absence of the computer system. There should be a backup plan such as allowing operators to submit emails in the absence of the CMMS and phone calls in the absence of the email. Planners should be able to scope jobs and prepare work orders with plans in the absence of the computer. Those paper minifiles also become very useful in the middle of the night when technicians with little inclination to log on need a simple piece of information on certain equipment. Do not be too hasty in discontinuing the collection of paper documents.

Another area of caution is cost assignment. The planner's estimate, the job hours recorded on employee timesheets, and the hours recorded on the returned work order itself may all differ. In addition, none of those three amounts may accurately reflect the hours the technicians did spend on the job. Computerization only automates what data is entered. Users of reports must be familiar with the possible shortcomings of analysis made from computer data.

Another new problem potentially arises after computerizing, especially when a company fully implements a sophisticated CMMS. Before having the CMMS, paper work orders moved sequentially from originator to planner to scheduler to supervisor to technician. There was always the occasional urgent work order that went from originator straight to the crew supervisor, but normally technicians did not receive unplanned work orders for routine maintenance. The work flow system kept the technicians from even knowing about the work prematurely. However, this changed with the advent of the information sharing CMMS. Now technicians and supervisors can routinely view new work orders for equipment in which they have an interest. A common scenario as this presents itself: A work order is written Thursday night, and on Friday morning a technician views the work order, prints it out, and completes the work, all without changing the computer status. Also on Friday, a planner views the work order, but because of the work order's low priority decides to plan it on Monday. On Monday the planner completes the plan and changes the status of the work order to waiting-to-be-scheduled. On Tuesday, the planning department clerk receives the completed work order papers from the field crew and changes the work order status to closed. The planner reviewing the work order paper is frustrated that the technician worked the job on an unplanned basis. Later when reports are run, because the computer indicated the job was planned, the crew gets credit for completing planned work. This type situation is not uncommon and requires management commitment and organizational discipline to manage. A successful planning effort aiding technicians with information from past jobs and aiding supervisors with scheduling control information both encourage crews to seek job plans before beginning work. A proactive, professional maintenance organization also helps.

Finally, computers add to the temptation to compile unnecessary metrics. Computers allow collection and arrangement of data much more easily in many cases, but certain metrics are unnecessary for proper management. The compilation of them wastes the time of analysts and managers. This is part of the distraction capability of a CMMS.

LESSER IMPACT WITH THE CMMS

Considering the CMMS an umbrella program that allows everyone to use common databases, there are certain maintenance functions that may not be major parts of the CMMS system. Some of this may be due to the impracticality of computerizing and some may be due to the avoidance of wanting "to reinvent the wheel."

First, there may be some areas that are impractical to computerize. For example, some maintenance practitioners profess wanting to eliminate paper documents totally. Many companies have paper morgues bursting with old documents. Yet, is paper elimination a practical objective? It seems that there should be room for a 1–2-inch minifile for each of 10,000 pieces of equipment. Is it also practical to scan entire O&M manuals into computer or microfilm archives and expect easy retrieval? Would the additional step of searching discourage planners from utilizing this resource? It may be best to allow planners easy access to fast scanners to scan specific sheets as they find them in O&M manuals and attach them to specific work order plans for jobs. In this manner, the planner builds the computer files while building the paper minifile with particular O&M pages.

Second, a single computer program that does everything may not do any one thing particularly well. CMMS programs tend to handle certain areas fairly well, such as equipment and work order history databases. However, other portions of the overall CMMS program may simply be focused on "providing a complete product." Areas where the CMMS vendor may have less expertise may be tool management, predictive maintenance, and document scanning and retrieval. Many CMMS packages deal acceptably with their limitations and form alliances with other software vendors. A CMMS vendor with less experience with imaging may incorporate the successful abilities of an imaging software developer. In this manner, the CMMS package is able to bring a best-of-class performance together under a single-umbrella program. In addition, some CMMS vendors are more adept than others at allowing their programs to communicate and integrate with existing software and programs that a plant already utilizes.

Predictive maintenance might be one area best left separate from the global CMMS. Predictive maintenance software has evolved to a high degree of performing trend analysis, analyzing fairly complex data. Many plants best leave the predictive maintenance group running its own software and keeping its own database of trends. However, the plant should insist that the PdM group should utilize the plant CMMS for maintaining equipment nameplate data and writing work orders. The PdM group should also utilize the same equipment identification numbers in its software. In effect, the PdM group functions as an independent laboratory providing specialized service to the plant.

TEMPLATES

Templates warrant a special comment with regard to the planning principles set forth in this book. Templates provide quick and easy solutions to common equipment problems. For example, a planner might have a pump with a problem. The planner might search a CMMS package's template function for pumps. The CMMS would show the common problems a pump might experience. Then the person might select which problem the pump has symptoms for and the CMMS would list common solutions for that problem. The planner could then select the desired solution and the CMMS would deliver a procedure for the job plan. The CMMS provides a master generic troubleshooting guide to boost planner efforts. In general, the problem with this approach is that the planner usually has adequate information to help determine the equipment problem. For one thing, the planner is a superior technician with specific experience with the plant's equipment. For another thing, individual equipment usually fails in only one or two favored modes that the minifiles should have well documented after even only a short time. For another thing, the technicians are usually skilled enough to make many repairs without having a generic procedure. What the technicians need are specific part numbers and other information recorded from previous jobs to avoid past delays. Generic repair procedures cannot contain this information because this information is specific to individual pieces of equipment, not types of equipment. Specific troubleshooting guides included in specific equipment O&M manuals are more helpful than generic templates contained in some CMMS packages. Overall, most templates are too general in nature.

LOGISTICS

Unfortunately, the decision to utilize a CMMS does not result in a computer being up and running the following morning with everyone fully familiar with how to use it. Will everyone use the computer after it is installed? Who should be involved with selecting a system and what is involved? What is some helpful advice on planning with a computer? This section addresses these issues.

First, whether everyone will use the CMMS depends on how user friendly the system is and the interest of the work force. With the advent of email to disseminate company-wide information, all levels of many companies are rapidly becoming computer literate. The rapid acceptance of using a CMMS may surprise many persons. One plant installed a CMMS at first only to track paper work orders and to provide equipment data for planners. Management at the plant decided that everyone should have the option of writing their work orders directly into the CMMS. The person actually responsible for implementing the system expected only 10 to 20% of new work orders to be directly entered. It was a great surprise that over 95% of the subsequent month's work orders were entered directly. The plant soon made the direct entry mandatory and eliminated the need for a clerk to enter work orders each morning.

One thing that seems to make a difference is having a special, user friendly screen that walks originators step by step through the process of entering the work orders. Another aid to helping persons utilize a CMMS is providing a slimmed down user's booklet. The typical thick volume published by many CMMS vendors contains more information than the typical person needs. The plant can publish its own versions of specialized instruction booklets for specific users. Appendix L contains sample slimmed down versions for planners and other users. Brief training showing specific helpful uses of the CMMS should be conducted by plant personnel familiar with the system. Training provided by the CMMS vendor on vendor supplied databases typically does not represent the screens as the plant has customized them nor does it utilize representative enough equipment. The vendor training may also dwell on modules the plant does not intend to implement. In addition, the vendor training may presume a maintenance approach not utilized by the plant. Key plant personnel, such as the plant individuals who understand the maintenance process and are leading the implementation of the CMMS, should take as much of the vendor supplied training as possible. Then these persons should train the different persons at the plant for their planned usage using actual plant databases and customized screens. Appendix L contains a sample plant-wide training outline. The planners will be the major users of the system, and the training for them will usually include much hands-on time from the plant persons implementing the system. Planners themselves will help develop the usage and customization of new modules to suit their needs. There should always be one or two persons at the plant site who can answer most questions of plant persons.

The second major issue concerns who and what is involved with selecting a system. The system is usually selected by a team following a usually predictable selection routine. The actual installation may proceed all at once or in predetermined phases over several years.

The persons involved in selecting a CMMS tend to be the planning supervisor and a representative from the IS group being led by a plant engineer. This group has frequent interaction with the maintenance manager. The maintenance manager may have to ensure that the IS group does not overwhelm the selecting group with inadequate maintenance process knowledge. It is also important that the plant engineer understands the planning and maintenance processes. Another person on this team should be a person that will become the system administrator. This person will set passwords and grant other rights to users. This person may also create standard reports and do some screen customization. It is preferred that the system administrator be a plant engineer or maintenance representative rather than an IS person for several reasons. The plant needs a local representative available to answer questions who understands the plant maintenance organization and processes. The system administrator choice should provide a person who will fulfill the role for years to come rather than as a current IS assignment. Many persons feel that it is better to have as a system administrator a maintenance person who develops an interest in computers rather than a computer person who becomes interested in maintenance. The system administrator should coordinate larger tasks of modification with the IS department or the CMMS vendor. Planners play a major role in utilizing a CMMS, but being a system administrator consumes a lot of time. It may be practical to have a planner fulfill this role if there is an abundance of planners, but this is usually not the case. Of course, for standalone, single user versions, planners may be the only users that directly enter or extract information. A planner would naturally be the choice system administrator. With this team of persons, the company might begin to select a CMMS. Teams such as this also frequently employ the use of a consultant to do much of the legwork and supply more familiarity with CMMS systems during the selection process.

The actual selection process tends to be somewhat the same for many companies. This is a very simplistic overview. Obtain a clear idea of the objectives of why management wants to buy a CMMS. Assemble a team for the selection. Obtain internal views of what system features are desired. Determine initial selection criteria. For example, some companies desire a CMMS vendor to be an established company that will stay in business. Some companies want specific industry experience. Some companies want geographical closeness for support. Some companies require a specific operating platform. Survey technical magazines for summaries of systems. List likely systems. Gather literature from these companies. Call and ask questions to see how they view maintenance. Expect to establish a long term relationship of support and continuing improvement. The ability of the company and vendor to work together as a team in the future should be evaluated along with the other technical requirements. Develop ideas of prices to review with management because complete systems range in price from under $1000 to well over $250,000. Invite vendors to make presentations and demonstrate systems. Refine and weigh selection criteria. Investigate selected systems. Check the claims of vendors where appropriate. Ask for unabridged users lists and call users. Visit other plants with the software. Call the CMMS support lines for responsiveness. Negotiate and sole source or bid final candidates. Do not expect any one system to be perfect.

One thing that surprises many companies is that the purchase price tends to represent only a fraction of the investment the company will make, perhaps only 20%. The company personnel to install and administrate the system consume an enormous amount of time. There is also the matter of computer equipment upgrades either initially or over time. The leading software vendors continuously upgrade their product. Usually a company pays a yearly license fee to have access to free upgrades and technical support. The CMMS vendor usually makes available an upgrade every other year or so and has a new major release every 3 to 5 years. These changes to the software come about because of the research being done by these vendors and because computer technology is evolving at breakneck speed. Thus, a company has to spend time and effort simply staying current with the latest CMMS software from the vendor already selected and utilized. If a company does not choose to install the latest software, the company risks soon having a system that neither the vendor nor the IS department can well support. This is not all bad. As computer technology evolves, companies may be upgrading their equipment anyway. In addition, the expenses paid to coordinate CMMS upgrades are investments in proper maintenance. Poor maintenance is very expensive as well.

Implementing new software also requires other expenditures and efforts. The data will have to be initialized into the new system. An inventory system already computerized might have to be downloaded into the new system. Who will make the links? Does the IS department have time to write these "scripts" and execute them? Many companies have a consultant who helped them in the CMMS selection or the CMMS vendor themselves help make the transfers. If this is planned, it should be part of the selection process. Computerizing inventory for the first time will require data entry. Does the maintenance organization have the time to do this? Can temporary help be hired? Who will direct their efforts? Can the consultant take care of this? Similarly, does equipment already have unique equipment tag numbers? Is there an existing database to transfer? If not, who will decide how to number equipment? Who will hang the tags and enter them into the CMMS? Will the CMMS have to communicate with other company programs such as payroll or inventory? Who will program these relations? The IS department typically is cautious with new programs interfacing with existing ones. Who will enter all the preventive maintenance tasks? Could the consultant supply clerical help to transfer an existing PM listing into the CMMS? In addition, as the new system is implemented, many specific details will have to be handled as they arise. Questions such as what to do if the new program mandates the use of a different term for waiting-for-scheduling will arise daily.

Also, do not presume that a CMMS must be installed fully all at once. It may never need full installation. If the company bought the CMMS for inventory and work order tracking, it is possible that labor calendars and vendor registries might wait forever to use. The equipment module might be initialized gradually as needed to reference work orders, and the company would be wise to soon initiate automatic generation of PM's. The planners might initialize the planning module gradually as they become familiar with the CMMS. Be cautious that some CMMS systems have used relational databases to such an extent that one cannot implement only a portion of a CMMS package. Appendix L shows a sample milestone schedule of the phased implementation of a CMMS. The decision on how to proceed with package implementation rests on many factors. These factors include mature judgments as to what value each feature of the CMMS holds, personnel and money available for implementation, and management's desire, willingness, or patience. Management may be willing to allow full implementation, but may not have the patience to provide support for a schedule of several years.

Some helpful advice on planning with a CMMS may include the following. Try to incorporate equipment numbers into job plan numbers. This will make it easier to use job plans for similar equipment as a starting point. For instance, different job plans dealing with equipment N02-FC-003 might be numbered N02-FC-003-1, N02-FC-003-2, N02-FC-003-3REBUILD, or N02-FC-003STRAINER. Each plan would have an equipment type code field to allow finding all the strainer plans. Similarly, have originators enter the equipment name at the beginning of the work order description even though there is a separate field for equipment name. For example, the problem description line would state "2A BFP leaking at seal." Reports that list the work orders will then make more sense. Have someone attend and participate in CMMS users' meetings. These meetings allow the CMMS vendor to grow and develop its product to be more helpful. Try to influence the product direction. Also, try to network with other users of the CMMS to exchange ideas and have contacts to call for advice. Buy computer typing games to improve planner keyboard proficiency if needed. A major question always arises regarding old closed work orders. Should they be entered into the system? It might seem relatively simple to have a clerk enter them, it is not at all practical to do so if the work orders reference no equipment numbers. Even if the equipment numbers are present, this effort may be unnecessary. The repetition of maintenance operations on specific equipment soon generates helpful information for maintenance planning purposes. There is not a critical need to enter past work orders and a strategy of work order entry "from this point forward" is frequently satisfactory.

SPECIFIC HELPFUL FEATURES FOR PLANNING AND SCHEDULING

From the standpoint of planning and scheduling as presented in this book, the following represent some helpful features that may not be common on some CMMS systems.

The CMMS would make it easy to enter actual job feedback and have a check-off for different job delays. It would be easy to update actual parts and tools used.

Most entries would be done from a minimal number of screens, preferably a single one that resembles what is printed out as the work order form.

The planner could go to an O&M type module that contains most equipment and job plan information, just like an actual physical O&M notebook. The planner can cut and paste from this manual to form job plans for individual jobs. The manual would in a sense have a master procedure detailing everything that could be done on the pump, complete with general steps, parts, and tools. This plan would actually be developed by the planner as new jobs are planned and feedback is received. With each new job, the planner would check the master to see if the details are present from which to cut and paste. Otherwise, the planner would add new steps to the master to represent this latest job. The entire CMMS would be backed up daily automatically, probably along with the network automatic routines.

The CMMS inventory function would automatically record the previous use of parts by equipment. This would provide an ongoing development of a parts list for each piece of equipment as maintenance works on jobs. Unfortunately, many CMMS inventory modules do not provide this automatic feature because they presume the plant has a complete set of parts lists for all its equipment. The modules primarily concern themselves with tracking quantities on hand and reservations for specific work order numbers.

The PM function could handle routes on multiple equipment and register the history with the individual equipment.

The company could easily add fields to link or track particular codes or information as needed.

One could easily find work orders and their status.

Supervisors could easily update job progress to help schedulers obtain backlog information.

Supervisors could easily keep on-line calendars to help schedulers obtain crew forecast information.

The scheduling routine would "work persons down" into lower skilled, but higher priority jobs as necessary to create the weekly allocation.

Supervisors could easily assign names into a weekly schedule for a single day.

Schedule compliance would be based on jobs started.

Timesheet information would form the actual cost collection, not feedback on work order forms.

Company would be easily able to implement the CMMS partially or in phases.

Email could be saved by equipment in the CMMS.

SUMMARY

Obviously, planning encompasses more than utilizing a computer. Nevertheless, a modern CMMS can be an important information tool. The planners need an accurate filing system, and the CMMS links a tremendous amount of information to individual pieces of equipment.

Many companies that implement CMMS packages are disappointed in the results. This disappointment appears to stem from only having vague expectations of what the results should be or how specific results were to be achieved. Disappointment does not need to be the case. CMMS packages contribute to the bottom line when purchased for specific information reasons. Although different types of computer systems are available, each can provide this information. Management can control and reduce inventory. Ad hoc and regular reports can provide management with necessary information to control the efforts of maintenance. The maintenance group can better visualize, determine, and manage its backlog with its resources. The maintenance group does have to be wary of becoming distracted with computerizing instead of maintaining the plant, but generally the computer should make a positive impact for its efforts. The CMMS cannot help a planning system that is floundering with the basics of planning such as knowing why to consult feedback from previous jobs. However, the CMMS can help in specific areas with the planning process.

This chapter has but briefly touched the wealth of available information in the literature for guiding companies in selecting a CMMS. If the company's role could be succinctly summed up, it might be with a statement by Nicholas Phillippi (1997). He says that "The best investment protection is a thorough understanding of the existing maintenance processes and application of the maintenance system in concert with these processes." Perhaps it should go without saying that the CMMS vendor should have significant maintenance expertise.

Understand, simplify, and then automate.