

Chapter 19

Maintenance Organization and Budget

Mankind's greatest invention is not the wheel but the bearing.
—Will Scott, Professor of Tribology,
Queensland University of Technology

Abstract The aim of this chapter is to describe the features and organizational structure used in asset maintenance and to show how the maintenance budget can be created and managed. *Outcomes* After reading this chapter you will be aware of the main features of the maintenance function including maintenance technical services, workflow management, and budgeting.

19.1 Maintenance Aim

The aim of maintenance is to deliver availability of machines and equipment to production or service departments, within the envelope provided by underlying machine condition and the available resources. Maintenance cannot convert a 10-year-old item into a new item, but it can sustain it in, or restore it to, a working condition consistent with its age, provided that this is technically and resource feasible.

19.2 Maintenance Organization

Logistic Support Analysis and Level of Repair Analysis as described in Chap. 17, when aggregated across the asset portfolio, provide the basis for determining the size and structure of the maintenance organization as a whole. In the case of a substantial in-house maintenance organization, the structure will be as illustrated in Fig. 19.1.

Further detail of the maintenance services function is indicated in Fig. 19.2.

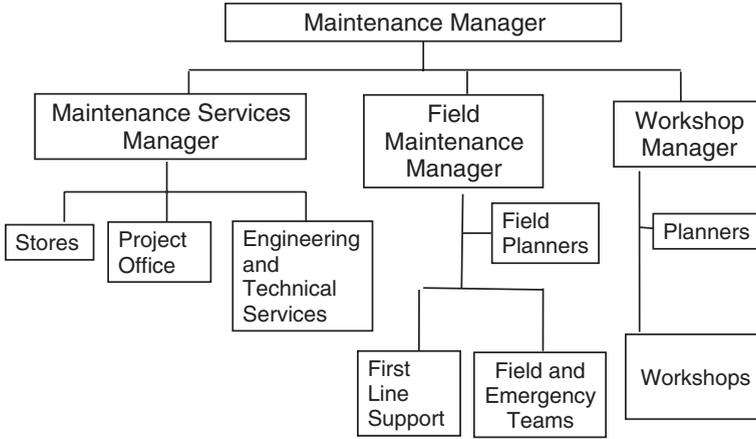
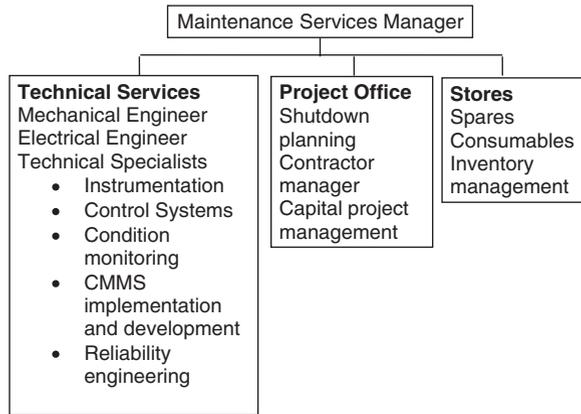


Fig. 19.1 Maintenance organization

Fig. 19.2 Maintenance services



19.2.1 Maintenance Layout

A typical physical layout of a maintenance organization is shown schematically in Fig. 19.3. At first line, this shows some maintenance personnel assigned to production areas A and B and some shown as supporting all areas. The split will depend on whether the production locations are widely separated, or have similar or different technology. Unless there are reasons to the contrary, it is advisable to have most of the maintenance support placed centrally to support all areas as this provides the most efficient use of the resources. Good planning, scheduling, and communications are important contributors to the efficiency of maintenance.

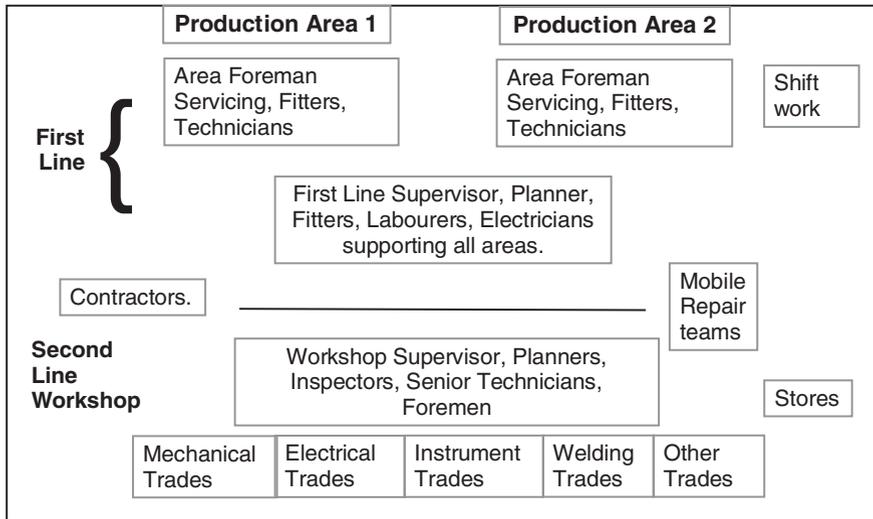


Fig. 19.3 Maintenance layout

19.3 Types of Maintenance Activity

A number of terms are used to describe maintenance activities and are summarized here. The categories are not necessarily mutually exclusive and some overlap may occur.

Routine Work carried out on a regular basis. Includes cleaning, lubrication, inspection, servicing, condition monitoring.

Emergency Action that must be carried out promptly in response to an urgent situation, may or may not involve actual breakdown.

Deferred Corrective work which can be carried out at a convenient time, in contrast to “emergency.”

Preventive Maintenance Maintenance aimed at preventing failures. Lubrication, servicing, component replacement on the basis of age or service time, such as an oil change at 10,000 km, or aero-engine deeper maintenance after a prescribed number of flying hours.

Predictive Maintenance Maintenance aimed at predicting potential failures and taking action to avoid in-service failure. Condition monitoring.

Corrective Maintenance Maintenance to correct known faults. May be Emergency or Deferred. Covers all activities other than routine. Includes activity carried out following conditions identified by reporting, inspection, condition monitoring, or breakdown

Breakdown Failure of an item or system occurs

Nonbreakdown Failure of an item or system does not occur, but action is needed

Scheduled Maintenance Maintenance which is part of a planned schedule. Can include routine maintenance, deferred corrective maintenance and shutdowns. Distinct from emergency maintenance.

Proactive Maintenance Root cause analysis and improvement activities.

Irregular Cyclic Maintenance is maintenance activity which can be expected to recur, though not in a strictly scheduled way. These activities may be triggered by normal observation or by condition monitoring.

Examples are the replacement of:

- tires
- engines
- batteries
- exhaust systems

Maintenance budgeting should allow for these activities, which will be ongoing and can produce significant but irregular costs.

19.3.1 Additional Related Tasks

It is common to find that the resources of maintenance are also drawn on for related tasks such as;

- Rebuilds
- Turnarounds
- Modifications
- Installation of new equipment
- Investigations
- Special functions or occasions

It is advisable to schedule all these activities in the same resource planning schedule in the Asset Management Information System or CMMS. This will provide for a balanced assessment of workloads and priorities.

19.4 Maintenance Work Management¹

The system must provide for and readily maintain:

- work requests;
- work order creation;

¹ D. Nyman and J. Levitt, "Maintenance Planning, Scheduling and Coordination," Industrial Press Inc.

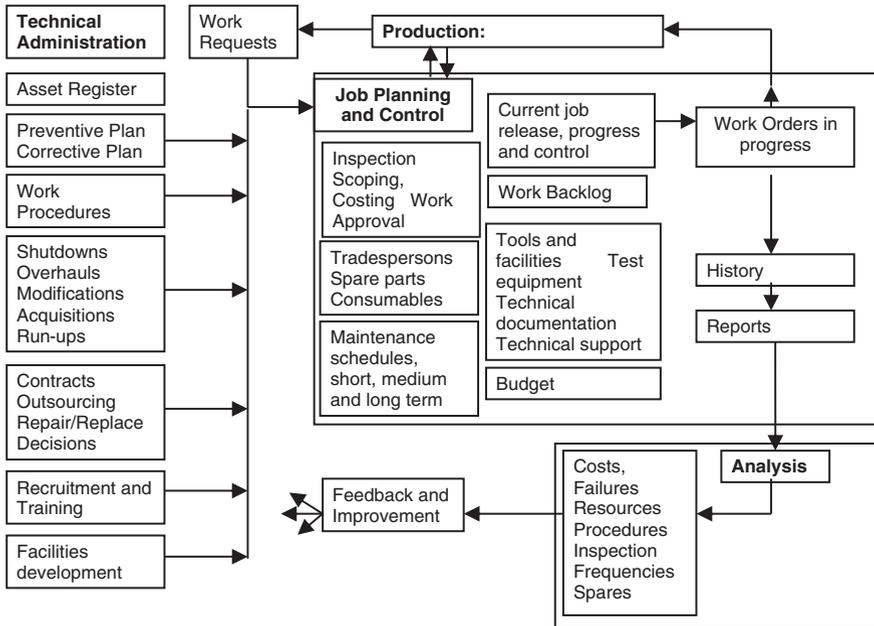


Fig. 19.4 Data flows in the maintenance management application

- list of current tasks;
- up-to-date status knowledge of current tasks;
- roster of resources—who is on duty when;
- schedule of assigned resources—who is doing what now and in the immediate future; and
- a rapid, secure, reliable, simple message passing system, typically based around work orders.

Figure 19.4 shows the data flows which are routinely handled in a maintenance management application of an asset management information system. The asset management system as a whole will also incorporate inventory management, costing, and budgetary management.

19.4.1 Inspection and Scoping

The first step in a maintenance task is for the job to be inspected and the scope of the work to be done to be defined. This leads into the next step which is job planning.

19.4.2 Planning and Costing

Planning is the process of identifying all the resources required to carry out a maintenance task. This includes:

- Trades and technical personnel to perform the task
- Materials and spare parts requirements
- Special tools and equipment required
- Support service requirements such as scaffolding or hire equipment
- Documentation, drawings, technical information required.

The output from the planning process is a Work Order containing all the above details and supporting documentation combined together to form a Work Pack for the task. At this stage the job is costed and approved as necessary.

19.4.3 Scheduling

The maintenance schedule defines when maintenance work will be done. Work will be included in the schedule on the basis of priority. Work will not be included in the schedule until it has been adequately specified by the maintenance planner.

Maintenance work schedules are normally produced weekly and confirmed prior to the start of the schedule commencement date. Except in the cases of an immediate priority (breakdown), the contents of schedules will only be changed by agreement between the relevant operations and the maintenance managers.

19.4.4 Maintenance Control

Maintenance and engineering related work is documented on work orders. All relevant work should be managed on the one work order system. Work Orders provide a basis for:

- Identification and tracking of jobs
- Work authorization and approval
- Work planning and assignment of job responsibility and resource utilization.
- Assignment and tracking of spare parts and materials
- Collection of equipment history and failure data for analysis.

19.4.5 Personnel Roles

Figure 19.5 shows the roles of personnel in the management of maintenance work.

Create Work Request	Anyone
Approve Work Request	Operations supervisor
Scope Work and Create Work Order	Inspector, Planner
Approve Work Order	Maintenance supervisor
Release Work Order when resources available	Planner
Schedule Work	Scheduler
Do work and provide feedback	Maintenance crew
Close Work Order	Planner

Fig. 19.5 Work management activities and typical roles

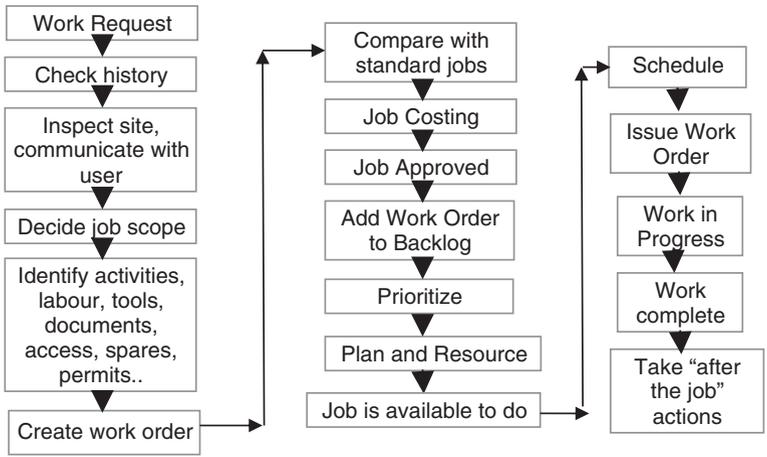


Fig. 19.6 Job scoping, planning, scheduling, controlling

19.4.6 Planning and Control Process

Figure 19.6 shows the sequence of events in the maintenance job planning and control process. In addition to the events shown, allowance must be made for *emergent work*, that is, work discovered as a job progresses.

Job Planner's Check List	
Before the Job	During the Job
<p>What</p> <ul style="list-style-type: none"> <input type="checkbox"/> Is there a Work Order <input type="checkbox"/> Is there enough information <input type="checkbox"/> Inspect site <input type="checkbox"/> Check equipment history <input type="checkbox"/> Is it a symptom of a bigger problem <input type="checkbox"/> Is there related work from the backlog <input type="checkbox"/> Is there an existing job plan <input type="checkbox"/> Establish scope of job <input type="checkbox"/> List sequence of activities <input type="checkbox"/> Is a follow-up job needed <p>Who</p> <ul style="list-style-type: none"> <input type="checkbox"/> Which trades are required <input type="checkbox"/> What hours per trade <input type="checkbox"/> Are special skills required <input type="checkbox"/> Relate to existing commitments <input type="checkbox"/> Identify sequence of activities <input type="checkbox"/> Is contractor work required <p>Spares, Materials</p> <ul style="list-style-type: none"> <input type="checkbox"/> What spare parts are needed <input type="checkbox"/> What materials/consumables needed <input type="checkbox"/> What is spares materials availability <input type="checkbox"/> Are rotables required <input type="checkbox"/> Is a kit required and checked <input type="checkbox"/> Is cannibalisation required <input type="checkbox"/> How will items get to site <p>Tools</p> <ul style="list-style-type: none"> <input type="checkbox"/> What special tools are required <input type="checkbox"/> What test gear is required 	<p>Access</p> <ul style="list-style-type: none"> <input type="checkbox"/> Communicate with production <input type="checkbox"/> Must machinery be stopped <input type="checkbox"/> Must the site be cleaned/cleared <input type="checkbox"/> How will persons and item get to site <input type="checkbox"/> Is space a problem <p>Documents</p> <ul style="list-style-type: none"> <input type="checkbox"/> What procedures are required <input type="checkbox"/> What drawings are required <input type="checkbox"/> What other documentation is required <p>Services</p> <ul style="list-style-type: none"> <input type="checkbox"/> Power and lighting requirements <input type="checkbox"/> Compressed air <input type="checkbox"/> Communications equipment <input type="checkbox"/> Cranes and lifting gear <input type="checkbox"/> Is scaffolding required <input type="checkbox"/> Workshop facilities <input type="checkbox"/> Transport <p>Safety</p> <ul style="list-style-type: none"> <input type="checkbox"/> What hazards are there; mechanical, electrical, chemical, biological <input type="checkbox"/> What hazard avoidance is needed <input type="checkbox"/> Are permits required, (e.g. hot work, confined space, elevated work, ground opening) <input type="checkbox"/> Are there statutory requirements <input type="checkbox"/> Are isolations required <input type="checkbox"/> Are tags required <input type="checkbox"/> Are emergency facilities needed
	<p>Proceed with all necessary work</p> <ul style="list-style-type: none"> <input type="checkbox"/> Report progress <input type="checkbox"/> Is re-scoping or follow-up work needed <input type="checkbox"/> Obtain progress related decisions <input type="checkbox"/> Report effect on other work <input type="checkbox"/> Communicate with production <input type="checkbox"/> Communicate with others e.g. stores, contractors, suppliers, engineering <input type="checkbox"/> Carry out tests and checks needed, operational, performance, alignment, balance, sealing^{60,66} <p>After the Job</p> <ul style="list-style-type: none"> <input type="checkbox"/> Tidy up <input type="checkbox"/> Hand over to production <input type="checkbox"/> Enter work in computer system <input type="checkbox"/> Close job off <input type="checkbox"/> Return unused spares/materials <input type="checkbox"/> Return tools etc. <input type="checkbox"/> Rotables - ensure repair in hand <input type="checkbox"/> Debriefing session <input type="checkbox"/> Update procedures, (include safety) <input type="checkbox"/> Update drawings <input type="checkbox"/> Update configuration documents <input type="checkbox"/> Initiate any follow up work required

Fig. 19.7 Job planners checklist

19.4.7 Planners Checklist

Figure 19.7 provides a checklist for job planners in relation to the creation and progressing of maintenance jobs (with acknowledgments to John de Haas).

19.4.8 Job Priorities Scheme

Figure 19.8 shows a scheme of job priorities.

19.4.9 Weekly Scheduling Process

Figure 19.9 shows the sequence of activities in creating and managing the schedule of maintenance work from week to week.

- | |
|--|
| <ol style="list-style-type: none">1. Emergency - immediate<ul style="list-style-type: none">Immediate safety hazardSerious impact on production or serviceActual or potential serious plant damageInfringes environmental safeguards2. Current – within 1 week<ul style="list-style-type: none">Potential to become priority 1 if unattendedReduces standby or backup capabilityNote: Routine maintenance slots in here.3. Short term – within 1 month<ul style="list-style-type: none">Desirable modifications to benefit personnel or efficiencyLikely deterioration in short term if not performed4. Medium term – within 2 months<ul style="list-style-type: none">Likely deterioration in medium term if not performed5. Long Term<ul style="list-style-type: none">Seen as advantageous but not essential in short or medium term. |
|--|

Fig. 19.8 Job priorities scheme

1. Each week the scheduler produces a schedule of work for the following week.
2. Assuming a week of Monday to Sunday, the schedule is produced on Thursday for the following week.
3. There is daily feedback on the schedule. The scheduler provides updates where needed but schedule stability is regarded as of considerable importance.
4. Some work will usually carry over into the next week.
5. The scheduler takes jobs on a basis of priority, drawing primarily from the available-to-do work in the backlog, and adds them into the schedule, until the available resources are committed.

Fig. 19.9 Weekly scheduling process

19.5 Maintenance Budgeting

19.5.1 The Business Plan

The starting point for maintenance budgeting is the business plan. In a mining operation, for example, the business plan will provide a production plan at each mine, and will give a planned number of tonnes of material to be moved in the year, in various categories such as overburden, ore, and processed material of various types. The plan will often be structurally similar to that for the previous year, but the quantities will vary to a greater or lesser degree. An increase or decrease in the mined and processed quantities will affect the maintenance workload, as will variations in such factors as the distance from the ore body to the processing units. In addition to the basic processes there will be many subsidiary activities which must be taken into account.

The fact that changes from year to year are often marginal is both a blessing and a curse. It is a blessing in that the maintenance workload, and hence the maintenance budget may then be derived by marginal changes, but it is a curse in that a considerable drift in the maintenance resources from those actually required can occur over time. Indeed, it is not uncommon to find that quite drastic changes in the maintenance workload by quantity and type have not been responded to in the maintenance budgeting process.

19.5.2 Zero-Based Budgeting

Zero-based budgeting is calculating a budget from first principles based on the current requirements of the business. In this approach, every item of the budget must be justified from first principles. During a pure zero-based budgeting process, no reference is made to the previous level of expenditure. This is in contrast to incremental budgeting which focusses on variances from past years, based on the assumption that the baseline is approximately correct.

19.5.2.1 Reasons for Zero-Based Budgeting

The reason for zero-based budgeting is that incremental budgeting can fail to keep up with changes in the business or the technology. Such changes may affect the workload by trades, by location and by operational requirements, and also create a need for capital equipment changes.

19.5.2.2 Limitations of Zero-Based Budgeting

Zero-based budgeting would seem to be the most logical way to form a budget. However, zero-based budgeting relies on the assumption that the needs of the business can be accurately assessed from first principles at every stage of the budgeting process. The end result may be that an essential item or service is missed or grossly over or underrepresented.

On balance we should always be alert to the need for a zero-based approach to any item, but should be sure to fully evaluate the possible reasons for the previous budget allocations and also take note of the “maintenance iceberg” visible later in this chapter.

19.5.3 Creating the Budget

The basic logic is summarized in Fig. 19.10.

The first step in Fig. 19.10, the production plan by type and quantity, must be provided by operations as part of the overall operational planning process. In Step 2 of Fig. 19.10, the maintenance budgeter analyzes the production plan to determine the corresponding machine requirements. The service level required by the business plan is a factor in determining the machine requirements. For example, in a railway operation, the timetabling plan will determine the required numbers of trains and this in turn will determine the availability level needed from the train fleet.

In Step 3 of Fig. 19.10 we determine the maintenance workload in order to meet the planned machine availability. This should be done as part of the total planning process. The success of the production plan will be dependent

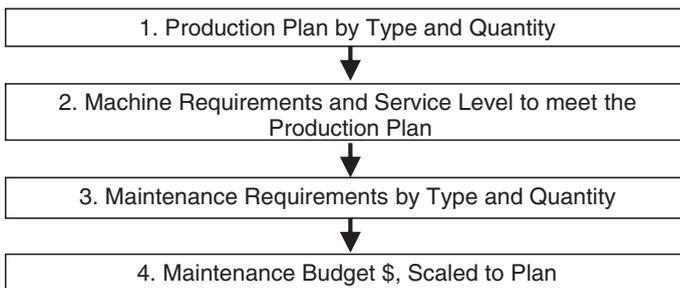


Fig. 19.10 Basic logic of the maintenance budget

on the ability of maintenance to service it, and the implications of the plan for maintenance physical and financial resources must be taken into account. The process continues over the range of maintainable assets, summarized to major blocks, with considerations of criticality, service level and required availability. Finally, the maintenance plan is used as a basis for creating the maintenance budget.

19.5.4 Using the History

Useful reference points at this stage are the operational loss data and work order data from the previous year. By analyzing operational loss data as an indicator of shortfalls in the past (such as canceled trains), and the work order data by trade, equipment, and location we can establish maintenance load per machine hour and in total. To be able to use the history data in this way, we must have been tough about requiring all operational performance data and maintenance jobs and hours to be reported. The analysis may make use of Pareto charts and pie charts to highlight where and how operational losses occurred and where maintenance money has been spent. This can turn up surprises, as the work done in particular areas may well be considerably out of kilter with expectations and with allocated resources. The operational loss data is useful as an indicator of achieved availability, and as an aid to focusing on loss reduction, to help justify the budget to operations and to senior management.

19.5.5 Walking Around

In addition to data analysis it is important to see the situation on the ground, particularly in regard to backlogs and equipment condition. Local management should be able to pinpoint areas of required capacity or surplus capacity on the basis of direct experience. Of course, local management will wish to have a generous allowance of resources and this must be aimed off for.

19.5.6 Backlog

Maintenance backlog is work which is either overdue or which is required to be done but has not yet been started. It is normal to have a moderate amount of backlog, particularly in regard to deferred corrective work which can be scheduled at a convenient time or on an opportunistic basis. However, excessive backlog is a danger sign in regard to the maintenance function. The budgeting process should allow for catching up with excessive backlog.

19.5.7 Sources of Maintenance Work

In developing the maintenance requirements consider the sources of maintenance work such as the following:

- Routine servicing
- Routine maintenance, e.g., inspect/check/adjust
- Corrective work arising at first line
- Existing backlog
- Condition monitoring
- Corrective work at second line (workshop) following from inspections
- Breakdowns and work requests. Subsequent repair/replace at first line
- Breakdowns and work requests. Subsequent repair/replace at workshop level
- Field repair teams if separate from previous categories
- Job scoping, costing, planning, and scheduling
- Technical supervision and support at tools level
- Technical support at engineer and specialist technician level including troubleshooting and reliability improvement
- Proactive maintenance, e.g., failure analysis, root cause analysis, conditioning monitoring development
- Data entry
- Data management, setup, analysis
- Modifications
- Installation and commissioning
- De-commissioning and disposal.
- Shutdowns/turnarounds, overhauls planning
- Shutdowns/turnarounds, overhauls implementation and management
- Ancillary and miscellaneous work—e.g., painting the Brownies' toadstools
- Personnel management
- Training
- Travel to and from site and work locations
- Spares and tools acquisition.

19.5.8 Changes in Demand

The considerations just outlined provide a basis for estimating demand for maintenance resources in the planning period. In practice much depends on how extensively the workload has changed from the current year and on how accurate we regard the current year's budget in the first place. If the workload has changed little and the current budget is seen as accurate, then minimal changes will be needed.

Changes to the level of equipment supported must be taken into account. For example, if 10 trucks work eight shifts per week this year, and 14 trucks will be working 10 shifts per week next year, then the budget should increase in proportion. In the case of increased workload those carrying out the work can be

expected to be vocal, but if the workload decreases, they are unlikely to mention it. It is up to management to identify the need for budgetary changes where workload had decreased, and to make the corresponding adjustments.

19.5.9 Direct Labor Estimates—Routine

The requirement for direct labor for routine maintenance can be estimated from the labor content and frequencies of particular routine maintenance activities. Figure 19.11 illustrates this.

19.5.10 Nonroutine and Breakdown Labor Estimate

The labor requirement for nonroutine work, which includes emergency breakdown and deferred nonroutine work, is estimated by reference to history, changes in forecast demand and by judgment. Additionally, breakdown costs can be estimated by considering the major failure modes, the mean time between such failures and the labor requirements per failure. The failures referred to here may combine chance events with cyclic events such as major assembly changes, the need for which can be predicted in broad terms, although the exact time of occurrence will not be known in advance. Figure 19.12 shows an example of nonroutine labor estimates for the various areas of a large mining shovel.

Aggregate Maintenance Workload Plan							
Mining Shovel PH-5000							
Std. Work Order	Freq/Year	Hours	Mechanical		Electrical		
			Persons	Pers-Hrs/Year	Hours	Persons	Pers-Hrs/Year
9716. 75hr lubrication system	64	0.5	2	64			0
1002 150 hour dipper inspection	32	1	1	32			0
1004 300 hour preventive maintenance	8	3	2	48	6	1	48
1398 600 hour preventive maintenance	4	6	2	48	6	2	48
1393 1200 hour preventive maintenance	2	8	2	32	10	2	40
1381 2400 hour preventive maintenance	1	12	2	24	12	2	24
1010 4800 hour preventive maintenance	1	24	3	72	24	3	72
Totals				320			232

Fig. 19.11 Labor estimates for routine work

19.5.11 Specific Items

We then make estimates of the workloads by trades and other roles for specific activities such as those shown in Fig. 19.13.

Aggregate Maintenance Workload Plan Non-Routine							
Mining Shovel PH-5000							
Asset Block	Mechanical			Electrical			
	Freq	Hours	Persons	Pers-Hrs	Hours	Persons	Pers-Hrs
Propel System	18	4	2	144	2	1	36
Swing System	6	3	2	36	2	1	12
Crowd System	48	2	1	96	1	1	48
Hoist System	48	1	1	48	1	1	48
House Assembly	6	1	1	6	1	1	6
Attachments	48	2	2	192	1	2	96
Air System	48	1	1	48	0	0	0
Lubrication System	24	1	1	24	0	0	0
Electrical System	96	0.5	1	48	2	1	192
Total				642			438

Fig. 19.12 Labor estimates for nonroutine work

	A	B	C	D	E	F	G
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							

Fig. 19.13 Specific items (headings only shown)

19.5.12 In-direct Labor

In-direct labor covers supervision, administration, training, stores, and technical personnel. Requirement for indirect labor must be estimated. Typically, there will be about 4 indirect positions per 10 direct positions. Examples of in-direct labor activities are,

- Supervision
- Technical administration
- General administration
- Training
- Induction, safety
- Systems development, e.g., Asset Management Information System implementation
- Documentation development and maintenance
- Equipment appraisal for acquisition, replacement
- Failure analysis
- Subcontractor management.

19.5.13 Overheads

Identify requirements for facilities and working and office space, consumables, telephone costs, and support for general administrative functions.

19.5.14 The Maintenance Iceberg

Many things in maintenance remain hard to quantify. For this reason, a *zero-based budgeting* approach, that is working the budget out by estimating the work to be done from first principles, is less effective than one would wish. Factors in the hard-to-quantify category include,

- Peaking of workloads for valid operational reasons
- Standby capacity to cover emergencies
- Standby capacity to mitigate against potential expensive downtime of key equipment
- Travel to and from jobs
- Acquiring and awaiting spares and consumables
- Acquiring tools and instruments
- Awaiting the completion of preceding work
- Subcontractor liaison, communication, management
- Acquiring permits
- Awaiting inspections

- Accessing documentation
- Gaining access to equipment
- Delays in bringing mixed trades together
- In-job training
- Diagnostics
- Resolving technical snags
- Obtaining technical advice
- Absenteeism
- Weather delays
- Seasonal variations
- Nonmaintenance activities of maintenance people
- Operator degree of care. Expensive consumables which can be wasted by careless operators should be moved to the production budget. Examples are tires, bucket teeth, ground engaging tools.

The marginal value of changes in the maintenance budget is hard to quantify on the downside as well as on the upside. Given more money, technical people can always find a use for it. On the other hand, the accountants' tendency to try to increase profits simply by making across the board percentage cuts can only work up to a point.

19.5.15 Arrive at the Resource Requirement

From the steps given in this section, arrive at a required capacity for each resource at each line of repair and at each location. The following categories of staff will typically be required:

- Tradesmen
 - Mechanical
 - Electrical
 - Civil, building, rigging
 - Instrument, air conditioning, etc.
 - Laborers
- Planners
- Storemen
- Inspectors
- Supervisors
- Engineering and technical support personnel
- Clerical staff
- Managers
- Data systems support staff
- Contractors.

19.5.16 Correct the Imbalances

Organizations may find that they have evolved into a situation where the workforce is out of balance with needs in terms of numbers, skills, flexibility, and location. Take a hard look for imbalances between current maintenance capacity and planned workload. Relate required work to required capacity by:

- Location
- Trade
- Shift
- Equipment type

Where imbalances occur—and they may not be small imbalances—reassign, reduce, or increase capacity. *Correct the gross imbalances.* Putting this another way, it means that while a totally zero-based budget approach may have its limitations, it is still good to be able to take a zero-based viewpoint in particular areas where there is reason to regard the resources as significantly out of balance. Build the result into the next year's budget.

19.6 Costing

The accounting department will help in converting the resource budget into a financial budget. This will involve identifying the cost rate for various labor categories including on-costs, such as,

- holiday pay,
- sick pay,
- payroll tax
- workplace insurance
- superannuation.

In-direct, operating, and overhead costs must then be added for such categories as,

- Vehicles,
- Tools and equipment
- Spares
- Consumables
- Freight
- Rent
- Rates
- Electricity and gas
- Telephone
- Facilities maintenance
- Insurance
- Office consumables
- Depreciation.

When in-direct costs and overheads are taken into account it is not unusual to find that the total cost of maintenance is in the region of six times the wages cost of the direct labor.

19.7 Survey and Quote

When a major item needs extensive work, a Survey and Quote approach can be used. The extent of work needed is assessed, possibly involving some disassembly, and a scope of work is determined. This is then costed and included in the budget. There must be adequate allowance for contingencies and for materials and overheads. The survey and quote and the subsequent work are often outsourced.

19.8 Budget Cost Control

1. Create a budget in a spreadsheet (or other established system) indicating the various cost categories and the amounts allocated. Figure 19.14 shows an example.
2. Record actual expenditure year to date (YTD) as it occurs.
3. Calculate planned expenditure for rest of year (ROY). In the absence of other information, this can be done as a proportion of the original budget, but it should be adjusted to allow for known factors of future expenditure. These may be increases or reductions relative to the original plan.

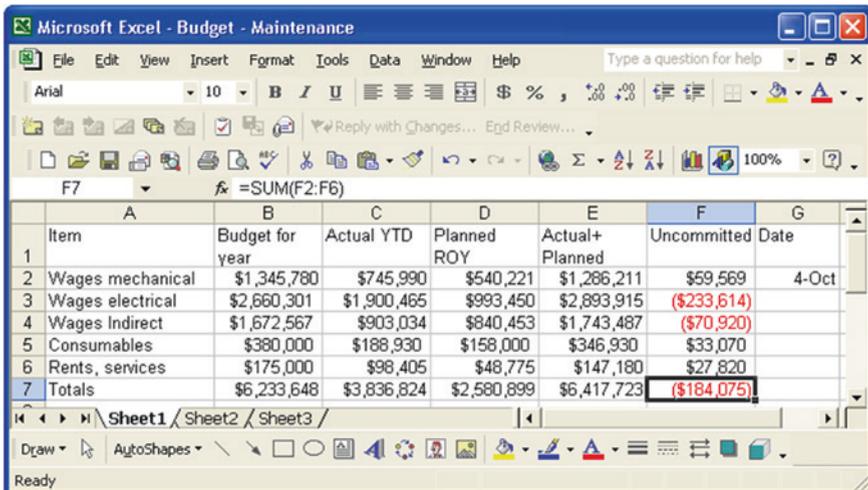
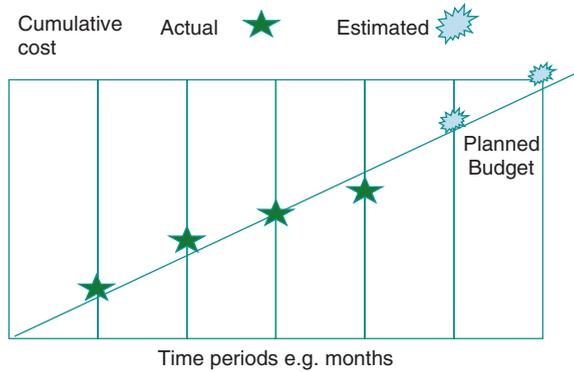


Fig. 19.14 Monitoring budget expenditure

Fig. 19.15 Budget actual versus planned



4. Calculate “uncommitted” money = Budget – (ActualYTD + PlannedROY). This will be a positive amount if there is a projected budget surplus and a negative amount if there is a projected budget shortfall.
5. Take steps to remain within budget, or discuss the situation with management if an unavoidable shortfall or surplus is emerging.

Figure 19.15 shows the budget monitoring process in graphical form. The expenditure planned in the budget is shown as the straight line (though in practice a variable slope may apply if expenditure over the year was not expected to be uniform). As time goes by the actual cumulative expenditure is plotted and the estimated cumulative is also shown, indicating projected expenditure in relation to budget.

19.9 Budget Reports

The following budget reports should be created and monitored on a regular basis, such as monthly.

1. Actual versus planned expenditure to date.
2. Estimated commitments versus remaining budget, giving projected *underspend* or *overspend*.
3. Risk analysis, i.e., significant costs which may occur, and also contingency which may not be required.
4. Informally, finance likes a realistic assessment of how much money will be needed. An overspend is a problem, but an underspend also needs to be addressed, and may relieve problems in other areas. Underspending often occurs due to delays in acquisition of items.
5. Although not specifically a budget report, backlogs in maintenance activity should be reported and monitored as part of the budget management process.

It is important to react in response to the information provided by the reports. Budget changes may be required due to significant changes in commitments.

Backlogs should be acted upon, either by increasing resources in backlog areas or reducing resources if backlogs disappear. Contingency allowances should be retired if risks do not eventuate. Do not cry wolf but be prepared to make a balanced statement regarding risk. Use the unfolding information to refine the budget for next year.

19.10 Activity-Based Costing

Activity-based costing means relating costs for a product, service, or machine closely to the activities needed to support it. This is in contrast to a broad brush approach which allocates overheads in proportion to direct labor, even when a particular overhead may not apply to a particular activity. Activity-based costing is a way of accurately allocating of overheads to the activity they are used on, and not to others.

In activity-based costing we

- Identify the “cost drivers” of each activity.
- Relate costs, and hence budgets and prices for these activities to the drivers.

19.10.1 Examples

In a certain plant, some food products require the use of high pressure steam generated by a boiler system. The boiler system is a cost driver for those products and should be taken into account when estimating their cost.

If activity-based costing is not applied, the cost of the boiler system might be spread over the whole plant (e.g., by absorbing the cost as a general overhead), wrongly inflating the cost of products which make no use of the boiler system. This can make those products appear noncompetitive with rival products in the market place which are not carrying the irrelevant overhead.

Internal invoicing between cost centers can provide a mechanism for assisting with activity-based costing. For example, in a power station which is close to a river it is important to monitor the stability of the foundations of the buildings. Initially, the workgroup monitoring stability of foundations was regarded as a general overhead. When internal invoicing was introduced, the monitoring workgroup invoiced the maintenance workshop for monitoring their foundations. The maintenance workshop was in an area that was not subject to instability and did not have its foundations monitored. They refused to pay and their refusal was upheld by senior management. Had they been required to pay for the monitoring of foundations as a general overhead, it would have artificially inflated their costs and made it hard for them to compete for outside work.

19.11 Exercises

19.11.1 Self-Assessment Exercise

1. What is the aim of maintenance?
2. Describe the following types of maintenance activity:
 - a. Routine
 - b. Emergency
 - c. Deferred
 - d. Preventive
 - e. Predictive
 - f. Corrective
 - g. Proactive
3. What is zero-based budgeting?
4. What steps form the basic logic of maintenance budgeting?
5. What is maintenance backlog and what part does it play in budgeting?
6. What factors in addition to direct labor go into the cost of maintenance?
7. How would you monitor budgetary expenditure?
8. What is Activity-Based Costing?

19.11.2 Maintenance Budgeting Exercise

Pacific Plant Management maintains a large fleet of earth moving equipment. You are creating a maintenance budget for the coming year. The following data are available for the current year (Table 19.1).

The direct labor cost rate is \$30 per hour with a multiplier for on-costs and overheads of 2.75. For the next year an increase in activity of 24 % has been forecast for all equipment types. A contingency allowance of 15 % is applied to the basic budget. What should the total maintenance budget be for the coming year.

19.11.3 Pacific Earth Moving Part 5: Maintenance

Pacific Earth Moving is in the process of acquiring a substantial amount of additional plant. The company has identified an area of profitable business in supporting mining

Table 19.1 Estimated maintenance hours and materials

Equipment type	Routine labor hours	Nonroutine labor hours	Spares and consumables
Trucks	30,000	10,000	\$195,000
Loaders	25,000	12,000	\$185,000
Excavators	28,000	15,000	\$205,000

and oil and gas industries. This involves providing equipment on contract, with full logistic support to major companies operating in remote and rugged terrain. The company needs to boost its maintenance support activities to meet this challenge. Your group has been retained to provide recommendations on the following issues:

- (a) What organization is needed to manage the maintenance of the equipment?
- (b) What functions will the maintenance organization need to provide?
- (c) How would you establish a budget for this maintenance activity?

Present your answer using charts and dot points.

19.12 Exercise Solutions

19.12.1 Self-Assessment Exercise Solution

1. *What is the aim of maintenance?*

The aim of maintenance is to deliver availability of machines and equipment to production or service departments, within the envelope provided by underlying machine condition and the available maintenance resources.

2. *Describe the following types of maintenance activity?*

Note These types of activity are not necessarily mutually exclusive, for example, condition monitoring is typically “predictive” and “routine.”

- a. *Routine Work* carried out on a regular basis. Includes cleaning, lubrication, inspection, servicing, condition monitoring.
- b. *Emergency Action* that must be carried out promptly in response to an urgent situation, may or may not involve actual breakdown.
- c. *Deferred Corrective work* which can be carried out at a convenient time, in contrast to “emergency.”
- d. *Preventive Maintenance* aimed at preventing failures. Lubrication, servicing, etc.
- e. *Predictive Maintenance* aimed at predicting potential failures. Condition monitoring.
- f. *Corrective Maintenance* to correct known faults. May be Emergency or Deferred. Covers all activities other than routine. Includes activity carried out following conditions identified by reporting, inspection, monitoring, or breakdown.
- g. *Proactive* Root cause analysis and improvement activities.

3. *What is zero-based budgeting?*

Zero-based budgeting is calculating a budget from first principles based on the current requirements of the business. In this approach, every item of the budget must be justified from first principles. During a pure zero-based budgeting process, no reference is made to the previous level of expenditure. This is in contrast to incremental budgeting which focusses on variances from past years based on the assumption that the baseline is approximately correct.

4. *What steps form the basic logic of maintenance budgeting?*
 - a. Start with the production plan
 - b. Machine requirements of the production plan
 - c. Maintenance requirements of the machines
 - d. Convert the maintenance requirements into costs
5. *What is backlog and what part does it play in budgeting?*
 Maintenance backlog is work which is either overdue or which is required to be done but has not yet been started. The budgeting process should allow for catching up with excessive backlog.
6. *What factors in addition to direct labor go into the cost of maintenance?*
 - a. In-direct labor
 - b. Overheads
7. *How would you monitor budgetary expenditure?*
 - a. Create a budget in a spreadsheet (or other established system) indicating the various cost categories and the amounts allocated.
 - b. Record actual expenditure as it occurs.
 - c. Calculate planned expenditure for rest of the year. There may be increases or reductions relative to the original plan.
 - d. Calculate “uncommitted” money. This will be a positive amount if there is a projected surplus and a negative amount if there is a projected shortfall.
 - e. Take steps to remain within budget, or discuss the situation with management if an unavoidable shortfall or surplus is emerging.

What is Activity-Based Costing?

Activity-based costing means relating costs for a product, service, or machine closely to the activities needed to support it. This is in contrast to a broad brush approach which allocates overheads in proportion to direct labor, even when a particular overhead may not apply to a particular activity. Activity-based costing is essentially an accurate way of allocating overheads.

19.12.2 Maintenance Budgeting Exercise Solution

$$\text{Cost} = \text{Direct-labor hours} \times \text{Cost rate} \times \text{Multiplier} \times \text{Annual increase}$$

Example: Routine for Trucks = 30,000 × 30 × 2.75 × 1.24 = \$3,069,000

Equipment type	Routine \$	Nonroutine \$	Spares and consumables	Total \$
Trucks	3,069,000	1,023,000	\$241,800	4,333,800
Loaders	2,557,500	1,227,600	\$229,400	4,014,500
Excavators	2,864,400	1,534,500	\$254,200	4,653,100
Total	–	–	–	13,001,400
Contingency	–	–	–	1,950,210
Total budget	–	–	–	14,951,610

19.12.3 Pacific Earth Moving Part 5: Maintenance Solution

a. See

Fig. 19.1 Maintenance organization,

Fig. 19.2 Maintenance services and

Fig. 19.3 Maintenance layout.

b. See

Fig. 19.4 Data flows in the maintenance management application,

Fig. 19.5 Work management activities and typical roles,

Fig. 19.6 Job scoping, planning, scheduling, controlling.

c. See

Fig. 19.10 Basic logic of the maintenance budget,

Fig. 19.11 Labor estimates for routine work,

Fig. 19.12 Labor estimates for nonroutine work,

Fig. 19.14 Monitoring budget expenditure.

Supporting points from Sect. 19.5.