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ROLLING STOCK NEED ASSESSMENT GUIDELINES

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Chapter 1

Introduction

Rolling stock need assessment is a process by which the future needs for equipment are assessed in view of the capacity to meet the demand for service. The required capacity of the operation and maintenance system that supports rolling stock for proper operation is also assessed throughout this process.

The guidelines for rolling stock need assessment presented here aim to help governorate and markaz rolling stock engineers to assess and improve available equipment performance and to determine the future needs for equipment, as well as to improve the system of operation and maintenance. These guidelines clarify the data engineers must collect, the steps they should follow, and the calculations they must make during the assessment process. In addition, the guidelines help them to make appropriate decisions based on the analysis obtained by applying the guidelines in the field.

BACKGROUND

Rolling stock that provides basic services, such as solid waste and wastewater disposal and road construction and maintenance, in the 22 governorates of Egypt represents considerable capital investment by both the government of Egypt (GOE) and the USA. The total value of this equipment is about $250 million, one third of it being decentralized support fund equipment. Despite being a large fleet, this rolling stock may not be sufficient to cover the demand for service in the governorates. In previous studies conducted in the 22 governorates, Chemonics has identified a number of constraints affecting the rolling stock sector, such as:

- Limited coordination between the current inventory of rolling stock, planned purchases and the actual service targets
- Unbalanced distribution of equipment and spare parts among the various operating sectors of the governorates, and lack of standardization which showed to be reflected negatively on the availability of some spare parts in the local market.
- Substantial equipment downtime resulting from inadequate maintenance
- Misuse of equipment and lack of skilled manpower

- Improper management of equipment use and inadequate management of the workshop maintenance and repair services

- Inadequate appreciation of the potential of the private sector for providing both basic service and equipment repair, which would supplement the governorates' capacity to offer these services.

An important part of the LD II-P effort over the past three years has been assisting the governorates to overcome these constraints. Within this frame of work, preliminary guidelines have been developed to help staff responsible for rolling stock in the governorates to assess the future needs for rolling stock as well as the capacity of O&M system elements. These preliminary guidelines have been revised and modified in this work, in view of the feedback obtained from field application in a pilot governorate, and put into a form that can be used by governorate officials.

INTRODUCTION TO THE GUIDELINES

The rolling stock need assessment process is summarized in Fig. 1.1.

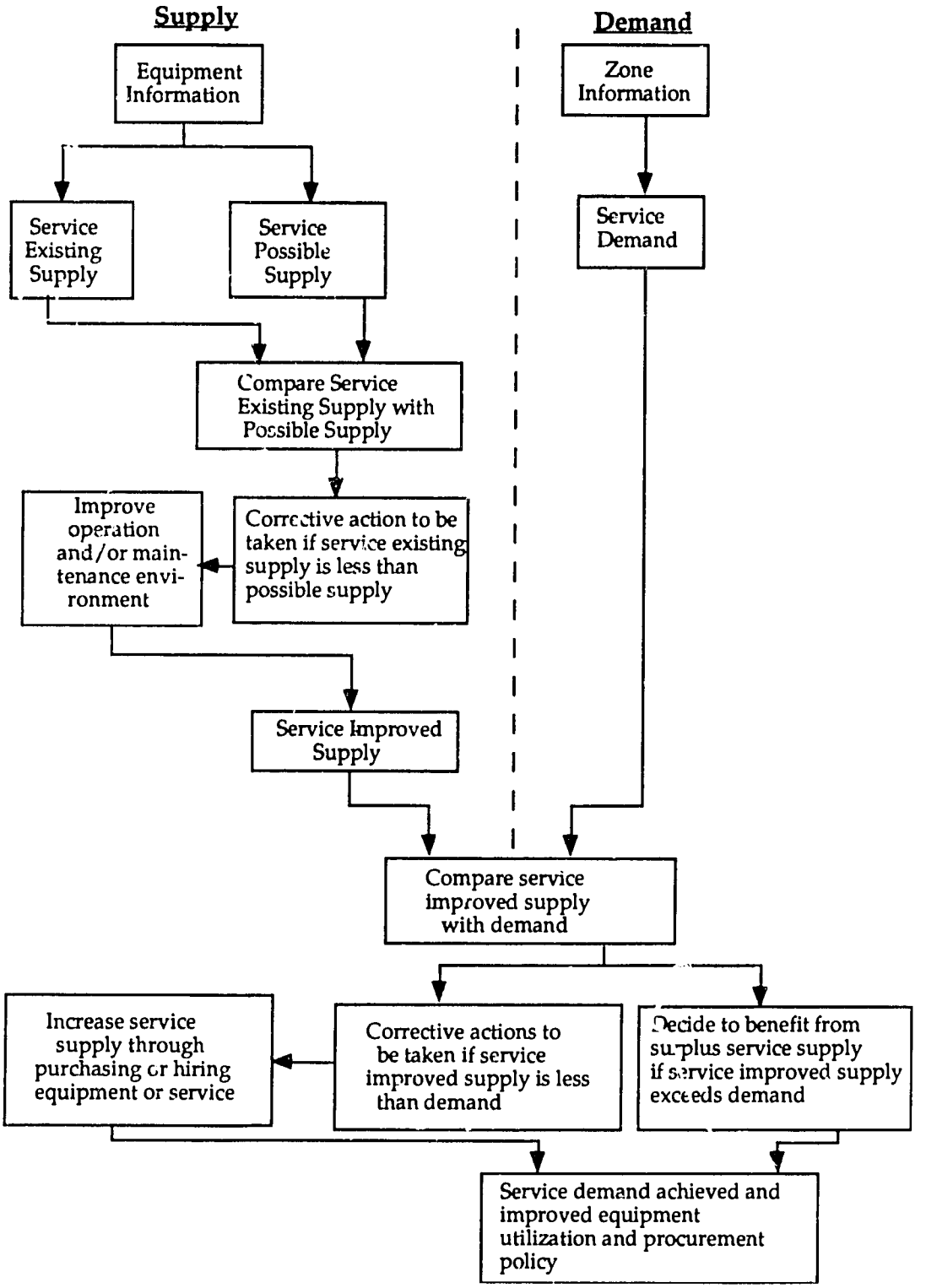
The first step in this process is to determine, in view of the conditions in the zone serviced, the demand for service from rolling stock during a whole year. The environmental and social conditions and the number of persons to be serviced must be considered. Two approaches for calculating the service demand are presented in Chapter 2. This chapter shows how to determine the demand for solid waste collection service and the demand for waste water collection service following the first approach, and the demand for road maintenance and construction service, using the second approach.

The second step is to determine the available equipment service supply and to take the corrective actions to improve it to approach its maximum possible value. Improved supply should then be compared with demand to determine the deficiency, if exists, that should be covered by additional equipment. Chapter 3 presents the details of this step, beginning with the process of gathering data about equipment for solid waste collection, wastewater collection, and road maintenance. Procedures to calculate the existing and possible service supplies of operational equipment follow for equipment for solid waste collection, waste water collection, and road maintenance, respectively. Comparison of existing and possible service supplies of

each type of equipment leads to the necessary corrective actions to improve the supply. The procedures for evaluating the service supply from the nonoperational equipment to be rehabilitated are then presented. With both the demand and supply of available equipment known, the need for additional equipment can be assessed.

Improved equipment performance can be achieved only when the capacity of all the O&M system elements meets the requirements of the rolling stock fleet. Methods of calculating the required capacities of the elements forming the O&M system are presented in Chapter 4. Available capacities of these elements are to be determined and compared with the demand for O&M, to discover shortages and cover them, as shown in Chapter 5. Chapter 6 summarizes the need assessment process and guides the use of the obtained results for decision making.

Figure 1.1


Supply
Demand
Equipment Information
Zone Information
Service Existing Supply
Service Possible Supply
Service Demand
Compare Service Existing Supply with Possible Supply
Improve operation and/or maintenance environment
Corrective action to be taken if service existing supply is less than possible supply
Service Improved Supply
Compare service improved supply with demand
Increase service supply through purchasing or hiring equipment or service
Corrective actions to be taken if service improved supply is less than demand
Decide to benefit from surplus service supply if service improved supply exceeds demand
Service demand achieved and improved equipment utilization and procurement policy

Chapter 2

Assessing Demand for Rolling Stock Service

The first task in identifying the need for rolling stock is to assess the demand for rolling stock service. This assessment is applied here in the three areas where rolling stock services are of prime importance namely solid waste disposal, wastewater collection, and road construction and maintenance.

Two general approaches are adopted for calculating the service demand. The first approach which best suits solid waste and wastewater collection requirements, is based on calculating the volume of waste products produced by the persons living in the zone that should be handled by rolling stock. The number of persons residing in the zone, the number of visitors to the zone, and the daily rate of waste produced per person should be known to calculate the total product of solid waste or waste water per year. The demand for rolling stock services is equal to the total waste products minus the volume of waste collected by the private sector or dissipated by other means.

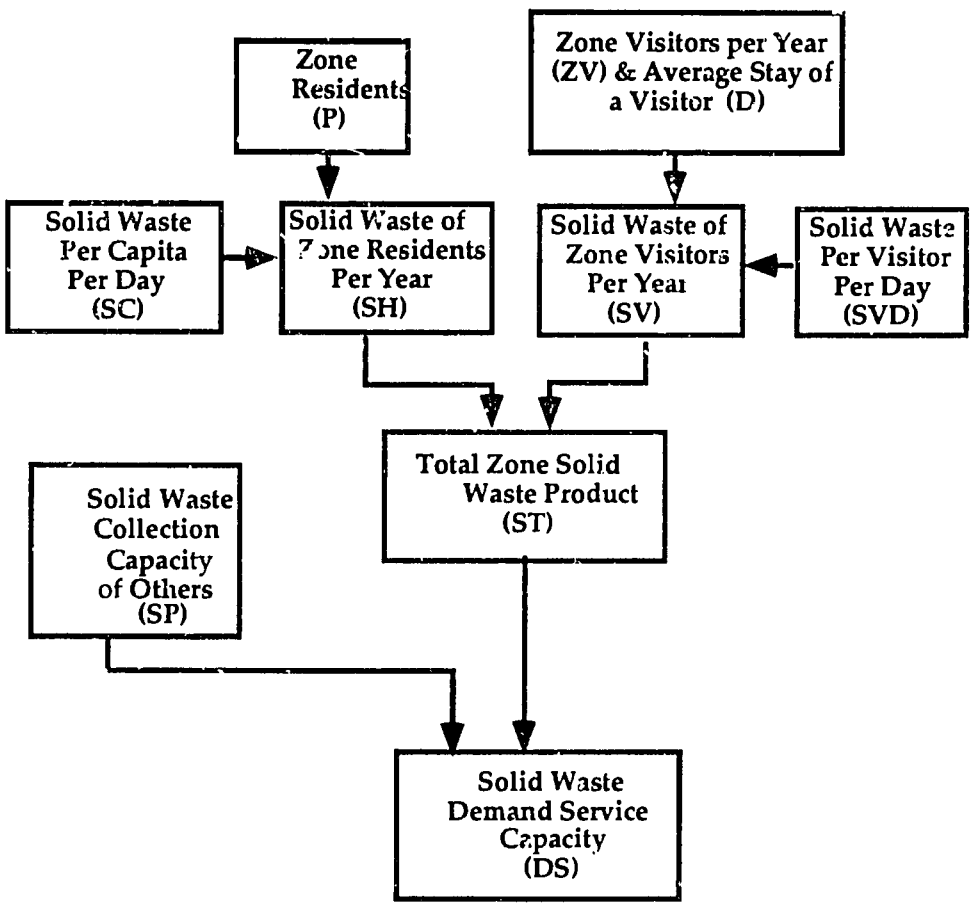
The second approach, which is suitable for calculating the demand for road equipment, depends on evaluating the volume of work needed per year. Knowing the length and width of the roads to be maintained, the frequency of maintenance activities, and the capabilities of the equipment used, you can calculate the service demand. The needs of dirt roads and asphalt roads should be calculated separately.

The following sets of procedures will guide you through the calculation required to assess demand in these three areas.

DEMAND FOR SOLID WASTE COLLECTION SERVICE

The following procedures will help up to estimate the equipment capacity needed for solid waste collection (DS). Figure 2.1, illustrates the flow of steps.

Fig. 2.1 Demand for Solid Waste Collection Service



SOLID WASTE FROM RESIDENTS

- Determine the number of persons (P) living in the zone to be serviced.

  P = ...person

- Estimate the average quantity of solid waste produced per capita per day (SC) in this zone by making a survey or by using an estimate in the range of 3 to 7 litres. In provincial areas the quantity may be about 4 liters and in urban areas about 5 liters.

SC = ...liter

- Determine the total solid waste produced per year from the zone residents (SH) using the formula:

$$SH = \frac{P \times SC \times 365}{1000} = \text{.....}m^3$$

SOLID WASTE FROM VISITORS

- Estimate the number of the zone visitors per year (ZV), and the average number of days of stay of a visitor in the zone per year (D).

ZV =.....person
D =.....day

- Estimate the quantity of solid waste produced per visitor per day (SVD). This quantity is expected to be a fraction of the solid waste produced per day of a zone resident.

SVD = ...liter

- Determine the total solid waste product per year from the zone visitors (SV), using the formula:

$$SV = \frac{ZV \times D \times SVD}{1000} = \text{.....}m^3$$

TOTAL SOLID WASTE PER YEAR

- The total amount of solid waste produced in the zone per year (ST) can be obtained by adding the totals of solid waste from residents and visitors

$$ST = SH + SV = \text{.....}m^3$$

SOLID WASTE COLLECTED BY OTHERS

- Determine the quantity of solid waste (SP) in m^3 that will be collected per year by others. Find this by calculating the total service capacity of the equipment owned by others.

PS =.....m^3

DEMAND SERVICE CAPACITY

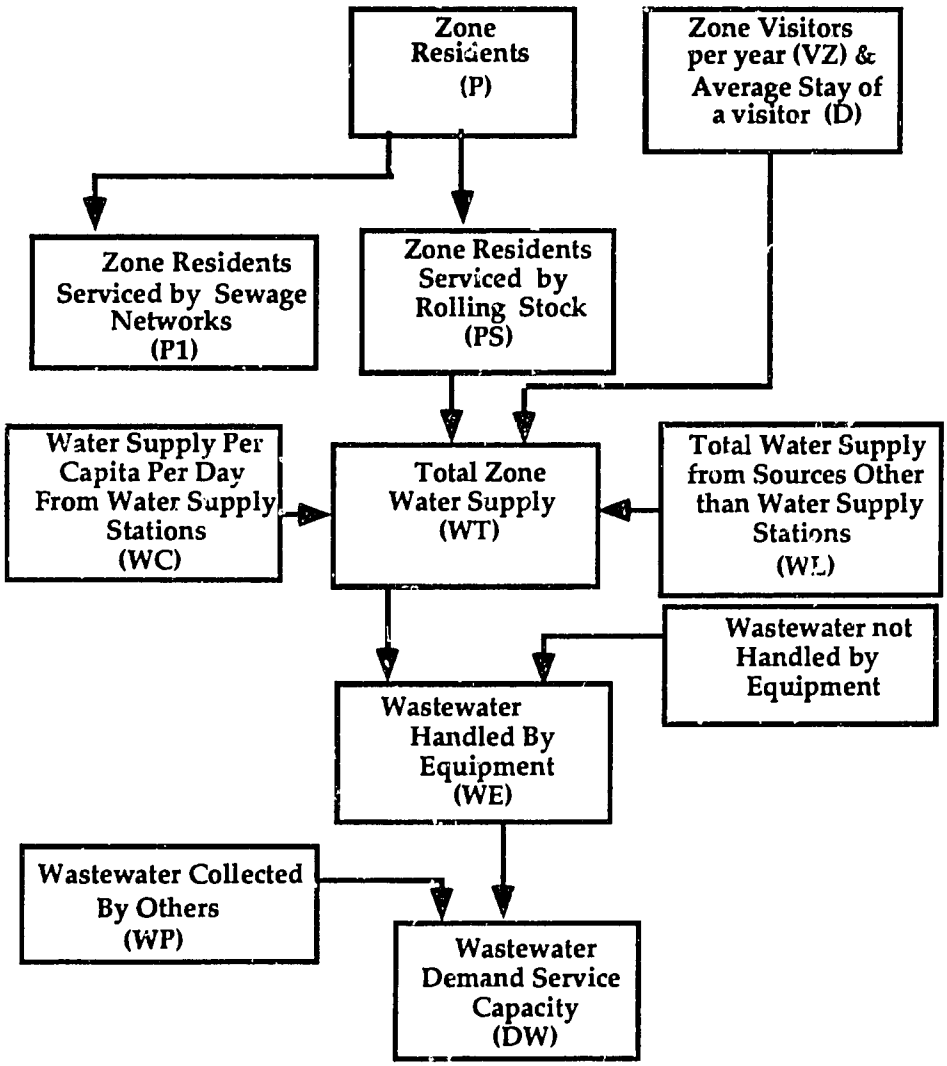
- The demand service capacity per year (DS) of the zone solid waste to be collected by rolling stock is determined by subtracting the total service capacity of the others from the total amount of solid waste produced.

$$DS = ST - SP = \text{.....}m^3$$

DEMAND FOR WASTEWATER COLLECTION SERVICE

The service capacity per year required of equipment used for wastewater collection can be calculated through the steps shown schematically in Fig. 2.2.

Fig. 2.2 Wastewater Collection Demand Service Capacity



RESIDENTS SERVED

- Determine the number of persons (P) living in the zone to be serviced.

P =.....person

- Determine the number of persons (P1) in the areas covered by sewage networks or channels conveying wastewater directly to the drainage.

  P1 = ...person

- Subtract the number in the second step from that in the first step, to find the number of persons living in the zone to be serviced by rolling stock (PS).

  PS = P - P1 =.....person

VISITORS SERVED

- Estimate the expected number of visitors per year to the areas to be serviced by rolling stock (ZV) and the average number of days of stay of a person per year in these areas (D).

  ZV =.....person
  D =.....day

QUANTITY OF WATER SUPPLIED

The water might be supplied to a zone from potable water supply stations or from other sources like wells or canals or else.

- Find the quantity of water supplied per capita per day in liters in the areas not covered by the sewage network (WC). You can find this information from potable water supply stations or from direct observations of water meters in houses in these areas. Usually this quantity is from 35 to 60 liters. In provincial areas it might average 40 liters and in urban areas about 50 liters.

  WC =.....liter

- Estimate the total quantity of water supplied per year to the areas not covered by sewage network from sources other than potable water supply stations, such as wells (WL) in m^3. This quantity can be estimated from field observations.

  WL =.....m^3

- The total water supply per year (WT) to inhabitants living in areas to be serviced by equipment can be calculated from the previous results, using the formula

$$WT = \frac{(PS \times 365 + ZV \times D)\ WC}{1000} + WL = \ldots\ldots\ldots\ m^3$$

QUANTITY OF WASTEWATER HANDLED BY EQUIPMENT

- Determine the quantity of wastewater, out of the total water supply per year, that shall not be collected by equipment for reasons such as:

  - Leakage from ditches to the soil. This can be taken as a percentage Y[1] of the total water supply (WT).

  - Water losses during transportation from water supply stations to houses, or wastewater discarded directly by throwing it into streets or canals (L), in m^3 per year. This amount would approximately be 5% of the total water supply per year (WT).

    L = .05 WT
    L =.....m^3

- The total amount of wastewater (WE) to be handled by equipment can be calculated using the formula.

$$WE = WT(1 - \frac{Y}{100}) - L = \ldots\ldots\ldots\ldots m^3$$

WASTEWATER COLLECTED BY OTHERS

- Determine the quantity of wastewater in m^3 that can be collected per year by the others equipment (WP). This should be done by calculating the service capacity of the equipment owned by the private sector.

WP = ...m^3

DEMAND SERVICE CAPACITY

- The capacity required per year (WD) of the zone wastewater collection rolling stock can be obtained by subtracting the private sector capacity from the total amount of wastewater to be handled.

WD = WE - WP =.... .....m^3

---

[1] The value of Y can be estimated through field visits to a sample of houses between two intervals of ditches drainage to determine the quantity of water supply (V) to these houses as recorded by water meters. If the total volume of the ditches of these houses is (D) then, $Y = (1 - \frac{D}{V}) \times 100\ \%$.

If D>V, then the surroundings add water to the ditches and Y would be negative.

If many cases, the value of Y is expected to be about 20%.

DEMAND FOR ROAD MAINTENANCE AND CONSTRUCTION SERVICE

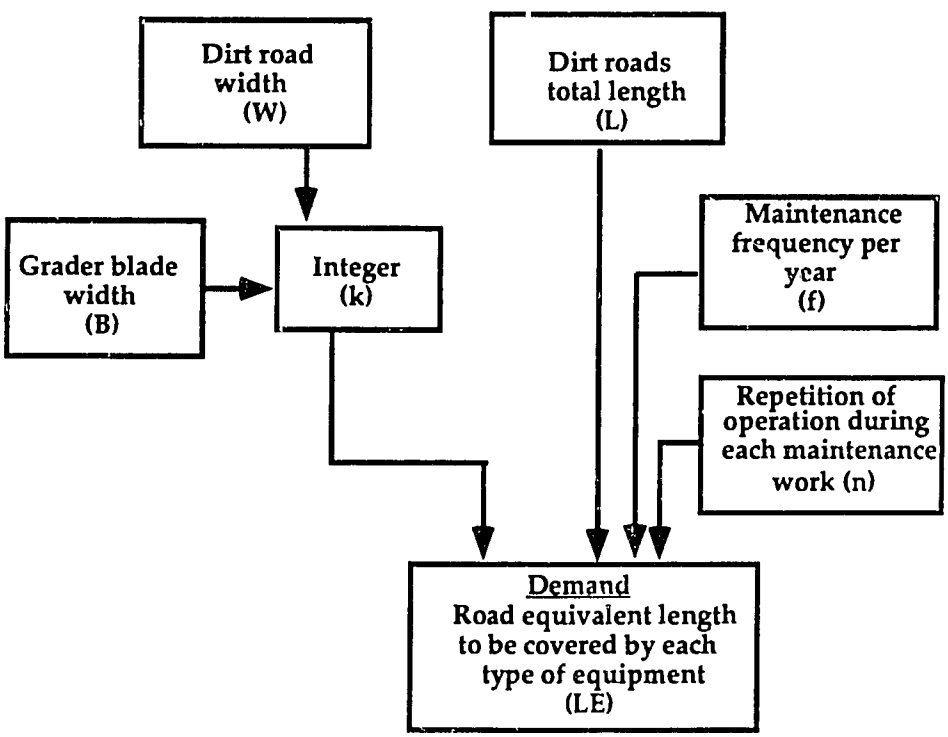
Governorate road department responsibilities include both road maintenance and construction. These departments generally use their own equipment for road maintenance. Road construction, on the other hand, is to be carried out by contractors from the public or private sectors, and the roads department responsibility in this case is only to supervise the work.

The following procedures allow you to calculate the demand for service from equipment involved in road maintenance.

DIRT ROADS

Fig. 2.3 shows a schematic drawing for the steps to determine the service demand of dirt roads.

Fig. 2.3 Dirt Road Maintenance Demand



Road Dimensions

- Determine the total length (L) in km and width (W) in m of dirt roads to be maintained using rolling stock.

L =.....km
W =.....m

Frequency of Maintenance and Operations

- Determine the frequency of maintaining these roads per year (f). For example, f is equal to 12 if the roads are to be maintained monthly.

  f =.....

- During each period of road maintenance, determine the number of repetitions (n) of the same operation. In most cases, road grading is carried out once, (n = 1), while water spraying is carried out twice, (n = 2).

  n =.....

Task Constant

- Determine the width of the blade of the available graders (B) in meters.

  B =.....m

- Now calculate the value of a constant k which is given by

  $$k = \frac{W}{B}$$

  If k is a fraction or contains a fraction, round it to the next higher integer. For example, if W = 6 m and B = 3.6 m, then k = 1.67. The value of k is thus set at 2. Supposing that W = 7.2 m and B = 3.6 m, then k = 2, and is set at the same value.

  In most cases the width of the grader blade is 3.6 m and the road widths range from 4 to 6 m. The value of k in these cases is 2. If a road width is less than 3.6 m, then k = 1, and if the road width is more than 7.2 m, k is more than 2 and should be calculated as shown above.

Length Covered

- Find the equivalent length (LE) in km to be covered during each operation in the year, using the formula:

  LE = L x f x n x k = ... km

Equipment Capacity

- Equipment capacity needed in this case is:

  Graders to cover the calculated distance per year.

  Water sprayers to spray water over the calculated distance per year.

ASPHALTIC ROADS

Asphaltic road repairs are of different forms, depending on the road conditions. Repairs might be made to improve the surface conditions by filling existing grooves with asphalt and rolling them or by covering all or part of the road surface with an asphaltic layer (road upgrading and rehabilitation). The latter type of repair is not dealt with in these guidelines, since it is considered construction work that is generally assigned to contractors from the public or private sectors.

Therefore, for asphaltic roads, road departments are concerned only with road surface improvement by filling the grooves.

Use the following steps to determine demand for service of asphaltic roads.

Repair Dimensions

- Determine for each groove the length (L) in m, the width (W) in m and the thickness (T) in cm. You may use the whole width of the road, and about 7 cm (2 cm more than the asphaltic layer thickness) as the thickness since you must remove the layer to reach the base course.
  L =.....m
  W =.....m
  T =.....cm

Quantity of Asphalt

- Determine the quantity of asphalt (q) in m^3 needed for each groove, using the formula

$$q = \frac{L \times W \times T}{100} = \ldots\ldots\ldots\ldots m^3$$

- Determine the total quantity of asphalt (Q) in m^3 needed for filling all grooves by summing up the quantities for each groove.

Necessary Equipment

- Equipment needed for this work is:

  Loaders and trucks for removing and transporting the old layer of asphalt (Q m^3), from groove locations to dump location.

Loaders and trucks for loading and transporting Q m^3 of new asphalt from asphalt mixing station to groove locations.

Rollers for asphalt compaction and levelling. The required number and working days of these rollers is to be determined considering groove locations, lengths and widths, and is to be estimated through adequate planning of the work year.

TOTAL DEMAND FOR ROAD EQUIPMENT

The total demand service for road equipment can be found for each type of equipment by summing up the demand for dirt and asphalt roads.

Chapter 3

Determining Rolling Stock Service Supply

The supply of equipment service should, in general, match the calculated service demand. To reach this goal, enough rolling stock should be available, in operation, and properly maintained. The following procedures help you to assess the service supply of the presently available equipment which when compared with demand will show the deficiency that should be overcome. The steps to be followed are summarized as follows:-

1. Gather information about the design capacities and performance of the equipment during the last year.

2. Calculate the service currently supplied by the available operational equipment (equipment in conditions 3 & 4[1]) on the inventory forms, as well as the possible service supply of this equipment.

3. Take steps to overcome reduced utilization and service supply of this equipment.

4. Estimate resulting modified service supply.

5. If this modified service supply is less than the service demand, remedy the situation by repairing and putting nonoperational equipment into service.

6. If a shortage in service supply still exists, hire or purchase enough equipment to bring the supply to the level of service demand. Alternatively, you can encourage the private sector to increase its capacity for basic service provision or to start offering such services.

---

1 Condition codes of equipment are those used in the DSF equipment inventory, namely:

0 = scrap, 1 = overhaul, 2 = medium repair, 3 = minor repair, 4 = good condition

DESIGN CAPACITY AND PERFORMANCE OF EQUIPMENT

Information on equipment service design capacity and performance may be obtained from technical catalogues, data sheets, equipment inventory, log books, and work orders. This information should be gathered and entered on the equipment data collection forms before you begin to calculate the supply of equipment service. These tables are designed to include all information needed for the calculation and analysis of the service supply.

Performance Data

- Enter performance data of the last year of all equipment for solid waste, wastewater, and road maintenance service on Tables 3.1 and 3.2.

Minimum Service Cycle Time

- Enter in each row of Table 3.3 the equipment type and the minimum possible filling and dumping times of the equipment, taking into consideration the time taken by operators for arrangement and installation.

- Enter also in Table 3.3 the average travel time of the equipment during one complete trip cycle. This includes the time taken to move from the garage or the dump location to the various clients till the equipment is completely filled, plus the time required to travel to the dump location. Sum the filling, dumping and travel times to obtain the minimum total time required to carry out one trip.

Annual Planned Work

- Table 3.4 gives the planned working hours or distance covered during a year for some equipment.

Table 3.1 Solid Waste OR Wastewater Equipment Data Collection Form

No.	Equipment Type, Code & Date of Entering into Service	Service Design Capacity		No. of Trips Per Year	Distance Covered Per Year (km)	Working Hours Per Year	Working Days Per Year			Non Working Days Per Year						Remarks
		Compact (ton)	Uncompact (m3)				Main Tasks	Other Tasks	Total	Fridays & Holidays	Main. & Repair	No Work Orders	Operators Shortage	Other	Total	
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																

Table 3.2 Road Equipment Data Collection Form

No.	Equipment Type, Code & Date of Entering into Service	Service Design Capacity(1)		No. of Trips Per Year	Distance Covered Per Year (km)	Working Hours Per Year (hr)		Working Days Per Year			Non Working Days Per Year			Projects				Total Work per Unit	Remarks
		Type	Value & Unit			Meter Reading	On Job	Main Tasks	Other Tasks	Total	No.	Reasons	Days	No	Name	Days of Stay	Quantity of Work & Unit		
1											1 2 3 4 5	Fridays & Holidays Main. & Repair No Work Order Operators Shortage Other Reasone		1 2 3 4 5					
2											1 2 3 4 5			1 2 3 4 5					
3											1 2 3 4 5			1 2 3 4 5					
4											1 2 3 4 5			1 2 3 4 5					
5											1 2 3 4 5			1 2 3 4 5					

(1) Enter service design capacity, namely type, value and unit. For example for graders: type is blade width, value and unit is the width in m. For loaders and trucks: type is bucket or box volume, value and unit is the volume in m3, ... etc.

Table 3.3 Trip Duration of Solid Waste and Wastewater Collection Equipment, and Trucks

Equipment Type	Minimum Filling Time (min) A	Minimum Dump Time (min) B	Average Travel Time (In&Out) (min) C	Total Trip Time (min) A + B + C

Table 3.4 Equipment Planned Working Hours or Distance Covered Per Year

Equipment Type	Refuse Truck	Dump Truck	Dump Trailer	Sewage Truck	Tractor	Truck	Bulldozer	Dumper	Grader	Loader	Roller	Water Spray Truck
lanned Work er Year	1800 hr	16000 km	16000 km	1250 hr	24000 km	24000 km	1250 hr	1250 hr	1250 hr	1250 hr	1250 hr	16000 km

EXISTING SERVICE SUPPLY

Existing service supply of rolling stock is defined as the supply of service from operational equipment (equipment in conditions 3 & 4) during the last year. For wastewater and solid waste collection equipment, existing service supply can be calculated when the capacity and the number of service trips made by each piece of equipment during the last year are known. This applies, in a similar way, to road maintenance and construction equipment. During calculations, it is assumed that the solid waste and wastewater collection equipment and the trucks and loaders are loaded during the service trips to their design capacity. If they were either under, or overloaded, the necessary corrections should be made by introducing a factor, which is less or more than one.

SOLID WASTE COLLECTION EQUIPMENT

Existing service supply of solid waste collection equipment can be calculated, using Table 3.5.

Equipment Information

- Transfer the information on existing solid waste collection equipment from Table 3.1 to Table 3.5. This implies filling in columns 2,5, and either 3 or 4 of this table.

- To transform the compacted capacity in tons of a compactor refuse truck to uncompacted capacity in m^3, multiply the compacted capacity by a factor c. This factor can be determined through field observations and would be about 5. Calculate this transformation and enter the result for each compactor in the fourth column of Table 3.5 headed *uncompact*.

Existing Service Supply

- Determine the existing service supply for each piece of equipment per year. You can calculate this by multiplying the uncompacted capacity in m^3 by the number of trips made per year.

- Sum the existing service supplies of all the equipment to get the total existing service supply.

Table 3.5 Existing Service Supply of Solid Waste Collection Equipment

No.	Equipment Type and Code	Service Design Capacity		No. of Trips Per Year B	Existing Equipment Service Supply A xB (m3)
		Compact (Ton)	Uncompact A (m3)		
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Total Service Existing Supply (m3)					

WASTEWATER COLLECTION EQUIPMENT

Existing service supply of this type of equipment can be calculated, using Table 3.6 as follows:

Equipment Information

- Use the information from Table 3.1 to fill in the first empty three columns of Table 3.6; namely equipment types and codes, equipment service design capacity and the number of trips made by each piece of equipment during the last year.

Existing Service Supply

- Multiplying the capacity of each piece of equipment by the number of trips it made last year to determine the existing service supply per year.
- The total existing service supply can be calculated by summing the existing service supplies of all equipment.

Table 3.6 Existing Service Supply of Wastewater Collection Equipment

No.	Equipment Type and Code	Service Design Capacity (m3) A	No. of Trips Per Year B	Existing Equipment Service Supply A x B (m3)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
Total Service Supply (m3)				

ROAD EQUIPMENT

- List each vehicle by type, giving its existing service supply on Table 3.7. This information is found on Table 3.2

- Calculate the total exisitng service supply for each type of equipment by summing the supplies of the individual units

Table 3.7 Existing Service Supply of Road Equipment

Equipment			Existing Service Supply per Unit	Total Existing Service Supply
Type	No.	Code		
Graders	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
Loaders	1			
	2			
	3			
	4			
Trucks	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
	9			
	10			
	11			
	12			
Water Spreayers	1			
	2			
	3			
	4			
	5			
	6			
Rollers	1			
	2			
	3			
	4			
	5			
	6			

POSSIBLE SERVICE SUPPLY

Possible service supply of the operational equipment (available equipment in conditions 3 & 4), in the three sectors dealt with, can be calculated as follows:

SOLID WASTE, WASTEWATER COLLECTION EQUIPMENT

To evaluate the possible service supply of wastewater and solid waste collection equipment, complete Tables 3.8 and Table 3.9.

Design Capacity

- Using Table 3.8 for solid waste collection equipment and Table 3.9 for wastewater equipment, enter for vehicle the design service capacity from Table 3.1. For compactor refuse trucks, the design service capacity is generally given in tons and should be transformed to uncompacted volume in m^3 through multiplication by a factor k. The value of k can be determined from direct observations and is expected to be about 5.

Possible Trips per Day

- Enter for each vehicle the total time required to carry out one trip as indicated in Table 3.3.
- Enter the possible working hours per day indicated in your O&M plans. For example, if one shift is worked, the work period is five hours for most equipment.
- Obtain the maximum number of possible trips per day by dividing the possible working time per day by the time taken for one trip. (Round the resulting number to the lower integer to account for the return trip to the garage).

Maximum Service Supply

- To obtain the maximum service supplied each day per vehicle, multiply the service design capacity (uncompacted in the case of compactor refuse trucks) by number of trips per day.
- Determine the expected number of working days per year for the equipment under consideration. This is 250 days for most equipment.
- To obtain the maximum service supply per year multiply the number of working days by the maximum service supplied by a vehicle per day.

Possible Service Supply

- Calculate the possible service supply of each vehicle as 90 percent of the maximum service supply. This is normally due to unforeseen factors such as incomplete filling of equipment or difficult road conditions. Whenever these factors do not apply in

your zone, set the possible service supply equal to the maximum one.

- Find the total possible supply of service by adding up the possible service supplies of all the equipment, and enter the figure at the bottom of the column.

Table 3.8 Possible Service Supply of Solid Waste Collection Equipment

Equipment Type and Code	Service Design Capacity		Total Trip Time (hr)	Working Hours Per Day (hr)	Maximum Trips Per Day	Maximum Service Supply Per Day (m3)	Working Days Per Year	Maximum Service Supply (m3)	Possible Service Supply (m3)
	Compact (ton)	Uncompact (m3)							
		A	B	C	D=C/B	E=AxD	F	G=ExF	
Total Possible Service Supply									

Table 3.9 Possible service Supply of Wastewater Collection Equipment

Equipment Type and Code	Service Design Capacity (m3)	Total Trip Time (hr)	Working Hours Per Day (hr)	Maximum Trips Per Day	Maximum Service Supply Per Day (m3)	Working Days Per Year	Maximum Service Supply (m3)	Possible Service Supply (m3)
	A	B	C	D=C/B	E=AxD	F	G=ExF	
Total Possible Service Supply								

ROAD EQUIPMENT

Rolling stock involved in road repair and construction activity can be divided into two groups: equipment for loading and transporting material and equipment for spreading material, levelling, and finishing.

Loading and Transport

Loaders and trucks are used for transporting material. The possible service supply of this type of equipment can be calculated using the same procedure as for solid waste and wastewater collection vehicles.

Spreading, Levelling, and Finishing

The possible service supply of graders, bulldozers, water sprayers, and rollers depends on the distance that can be covered by each type per day. For instance, graders are expected to cover a distance of 10 km/day, while grading roads and a distance of 4 km/day while spreading road material . Bulldozers should cover a distance of 6 km per day while spreading material.

Calculate the possible service supply of each type by multiplying the distance to be covered per day by the number of operational vehicles and by the number of working days per year.

The possible service supply of rollers and water sprayers is interlinked with the possible service supply of graders and bulldozers.

Table 3.10 Service Possible Supply of Loaders and Trucks

Equipment Type and Code	Service Design Capacity (m3) A	Total Trip Time (hr) B	Working Hours Per Day (hr) C	Maximum Trips Per Day D=C/B	Maximum Service Supply Per Day (m3) E=AxD	Working Days Per Year F	Maximum Service Supply G=ExF	Possible Service Supply (m3)
Total Possible Service Supply								

COMPARISON BETWEEN EXISTING AND POSSIBLE SERVICE SUPPLIES

The comparison between the existing service supply and the possible service supply will show whether the present service supply is less than, equal to, or more than the possible service supply. This implies that the ratio (X) between the existing and possible service supplies is less than, equal to, or more than 100%. Reasons for this should be analyzed in view of equipment utilization and productivity. Calculation of equipment utilization is based on the assumption that the equipment is filled to the design capacity during each service trip.

EQUIPMENT UTILIZATION

Enter actual recorded working hours or distance covered during the year for each vehicle in Table 3.11.

This is recorded in Tables 3.1 and 3.2. Planned working hours or distance covered for each type of equipment are recorded on Table 3.4.

Percentage Utilization

- Calculate percentage utilization for each piece of equipment by dividing the actual working hours or distance covered by the planned values obtained from Table 3.4. Enter the percentage utilization in Table 3.11.

Average Percentage Utilization

- To find the average percentage utilization of all equipment of the same type, sum the actual working hours, or the distance covered, of all equipment of the same type; divide the result by the number of vehicles to get the average actual working hours or distance covered; divide this result by the planned value to get average percentage utilization.

Table 3.11 Equipment Utilization

No.	Equipment Type and Annual Planned Work	Equipment				Total Actual Work/Year	Average Percentage Utilization
		No	Code	Actual Work Per Year	Percentage Utilization		
1	Refuse Truck (1800 hr)	1 2 3 4 5 6					
2	Grader (1250 hr)	1 2 3 4 5					
3							

ANALYSIS OF PERCENTAGE UTILIZATION

Based on the results in Table 3.11, three cases are possible:

AVERAGE HIGH, EACH HIGH

Average percentage utilization is high and the percentage of each piece of equipment is high. The following table shows the values of the equipment percentage utilization (U) and the values of the ratio between the existing and possible service supplies (X) that are considered high in relation to the working years of the equipment.

Number of Years of Service	Up to 3 Years	From 3 to 5 Years	More than 5 Years
U	>90%	>85%	>80%
X	>90%	>85%	>80%

For Equipment working for more than five years, but overhauled, the values of U and X would be considered high if they are more than 85 percent.

This case implies that the equipment is in good technical condition with no problems in equipment maintenance and operation faced.

AVERAGE HIGH, SOME LOW

Average percentage utilization is high, but percentage utilizations for some equipment is low. This implies problems in maintenance and/or operation for equipment with low utilization.

AVERAGE LOW, MOST LOW

Average utilization is low, as is that of most equipment. This indicates problems in maintenance and/or operation of most equipment.

In the last two cases, problems exist in the following areas for equipment with low utilization.

Maintenance and repair

- This may be the problem area if the equipment remains in the workshop for a long period. To determine this, look at the details of the equipment non-working days in Tables 3.1 or 3.2.

  If inadequate maintenance and repair is the problem, the reasons may be some or all of the following:

  Lack of spare parts

  Lack of adequate space, tools, machines, or materials necessary for maintenance and repair work.

  Lack of skilled maintenance and repair personnel

  Lack of incentives for persons working in the workshops

  Lack of funds necessary for repair work

  Weak management of the workshops

  Other reasons pertinent to the zone

Operation

- If the equipment with low percentage utilization is in good technical condition and is capable of offering service during the planned number of days per year, the problem may be operational, and could be attributed to some or all the following:

  Insufficient working orders

  Insufficient number of working staff

  Lack of incentives for the working staff

  Deficiency in financing the operational work

Weak management

Other reasons pertinent to the zone in which equipment offers service

Measures should be taken to increase equipment utilization by overcoming these constraints.

SERVICE SUPPLY AND PERCENTAGE UTILIZATION

Equipment with 100 percent utilization can ultimately yield service equal to the possible service supply. If, for instance, utilization is 100 percent but the existing is less than the possible service supply, modifications in the operational conditions could increase the existing service supply. This applies as well if, for instance U is found to be 125% while X is equal to 100%.

Increasable Service Supply

Generally, possible increase in the service supply exists when the ratio (X) of the existing service supply to the possible service supply is less than the equipment percentage utilization (U). Using Table 3.12, follow the next steps for the calculations involved.

- For each vehicle enter the percentage utilization (Table 3.11), possible service supply (Tables 3.8, 3.9, 3.10), and existing service supply (Tables 3.5, 3.6, 3.7) on Table 3.12.
- Divide existing service supply by possible service supply to get the ratio (X) for each vehicle.
- Compare (X) with percentage utilization (U). Where X is considerably less than U, or X/U is a fraction less than 0.95, service supply can be increased.

Table 3.12 Relation Between Equipment Service Supply and Utilization

Equipment Type and Code	Equipment Utilization(U%)	Possible Service Supply per Unit A	Existing Service Supply per Unit B	X% B/A	X/U

Reasons for Reduced Supply

Reasons for a reduced service supply when X/U is less than 0.95 might be:

- Misuse of equipment
- Not enough skilled operators
- Lack of incentives for operators
- Unbalanced work systems
- Weak management
- Others reasons pertinent to the zone such as using large equipment in areas with narrow streets.

Overcoming Reduced Supply

When X < 0.95 U, measures should be taken to overcome the reasons of service supply deficiency. Depending on the reason for the deficiency and the possible actions to be taken for remedy, an improved service supply can be attained and estimated.

Reasons for equipment underutilization and low service supply as well as the actions to be taken for remedy are expanded in Appendix A.

IMPROVED SERVICE SUPPLY AND ITS RELATION TO DEMAND

IMPROVED SUPPLY

A summary of the steps to reach the improved service supply is as follows:

- Determine the existing service supply
- Determine the possible service supply (PSS)
- Determine the value of the factor (X) which equals the ratio of the existing service supply to the possible service supply.
- Determine the percentage utilization of equipment (U).
- Take the necessary measures to raise the equipment percentage utilization to Ui.
- Take measures, improve the factor X to Xi such that Xi/Ui is higher than 95 percent.
- Calculate the improved service supply, which equals the PSS x Ui x Xi/Ui.

SUPPLY VS DEMAND

When you compare the improved service supply with the service demand, three cases are possible:

- Improved service supply is greater than service demand. In this case more operational equipment is available than needed. Decision should be made to make beneficial use of both excess operational equipment and nonoperational equipment.

- Improved service supply is nearly equal to service demand. Operational equipment in this case is just adequate for covering the service demand. Nonoperational equipment is thus redundant. A decision should be made to find a beneficial use for it.

- Improved service supply is less than service demand. Nonoperational equipment should be used in this case before looking at other means of service supply.

NONOPERATIONAL EQUIPMENT

Nonoperational equipment would be in conditions 0, 1 or 2. While all equipment in condition 0 are to be scrapped, some of those in conditions 1 and 2 should also be discarded because of high repair costs or lack of spare parts.

Figure 3.2 shows the procedures for determining the equipment to be rehabilitated and the arising cost.

EQUIPMENT REHABILITATION

To obtain the necessary information complete Table 3.13 through the following procedure:

Rehabilitable Equipment

- Assess the conditions of the non-operational equipment and exclude the scrap equipment (equipment in condition 0).
- List equipment in conditions 1 and 2 and determine rehabilitation work to be done

Spare Parts Availability

- Indicate whether or not the necessary spare parts are available.
- Delete equipment which has been non-operational for more than two years because spare parts were not available.

Repair Work

- Determine the repair work that can be carried out in the markaz maintenance center (MMC) and enter the cost and duration of each repair.
- Determine the repair work that would be done in public and/or private sector workshops and indicate the cost and time for each repair. (This can be carried out, for instance, through a tendering process).

Cost Evaluation

- Determine in view of the cost, time, policy, and laws, which organizations should be assigned the repair work. Calculate the total rehabilitation cost for each piece of equipment.
- Exclude the equipment that require more than 50 percent of its replacement price for rehabilitation.
- The remaining equipment is the equipment that would be rehabilitated.
- Calculate the total rehabilitation cost of the remaining rehabilitable equipment by adding together the rehabilitation costs of all the equipment.

FIG. 3.1 REHABILITATION WORK AND COSTS - FLOW CHART

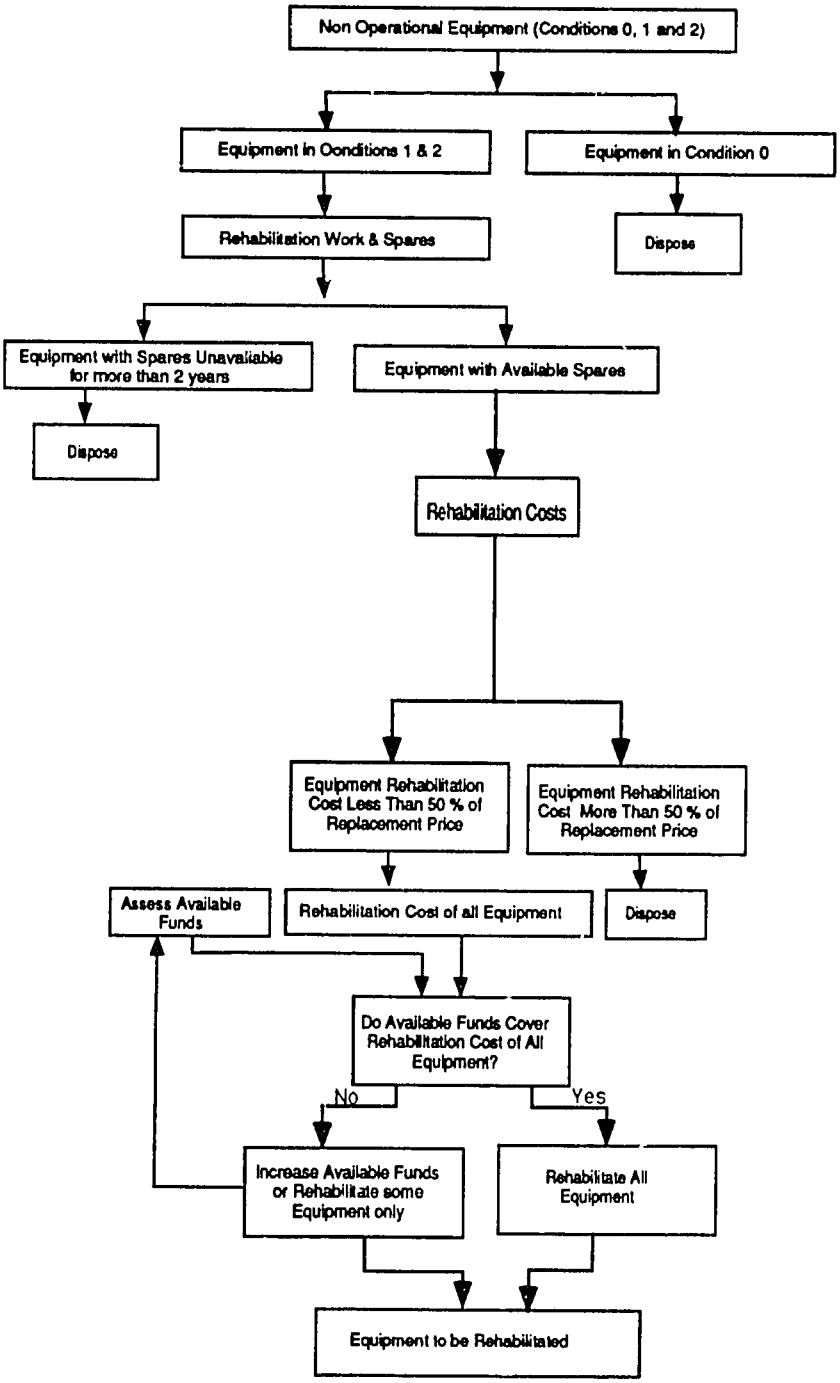


Table 3.13 Rehabilitation work and cost for nonoperational equipment

Serial No.	Equipment Type & Code	Required Repairs		Are Spares Available (Yes/No)	MMC Repairs		Public Sector Repairs		Private Sector Repairs		Chosen Organi-zation	Cost per Item LE	Total Cost LE	Remarks
		No.	Type		Cost LE	Time (days)	Cost LE	Time (days)	Cost LE	Time (days)				
		1												
		2												
		3												
		4												
		5												
		1												
		2												
		3												
		4												
		5												
		1												
		2												
		3												
		4												
		5												

Available Funds

- Determine the available funds for equipment rehabilitation.
- Compare the available funds with the total rehabilitation cost.
- If the available funds cover the total rehabilitation costs, all of the equipment can be rehabilitated.

Additional Funding

- If the total required rehabilitation costs exceed the available funds, take the necessary measures to increase the funds to rehabilitate the equipment or choose to rehabilitate only some of the equipment. The number and types of equipment in the latter case should be determined by considering the equipment's designed service capacity, compatibility with working conditions in the zone, and the equipment standardization policy.

Enter details of nonoperational equipment that should be disposed of in Table 3.14.

Table 3.14 Equipment to be Discarded

Equipment Type & Code	Manufacturer	Year of Production	Total Distance or Working Hours	Dates of Overhauls Made			Reasons of Disposal
				1	2	3	

SERVICE SUPPLY OF REHABILITATED EQUIPMENT

- Determine the possible service supply of the equipment that shall be rehabilitated.
- Remedy the situations that might lead to equipment underutilization or reduced service supply, as shown in Appendix A.
- Calculate the attainable service supply of rehabilitated equipment. This equals the possible service supply of rehabilitated equipment times improved service supply of operational equipment, divided by possible service supply of operational equipment

TOTAL AVAILABLE SERVICE SUPPLY & ITS RELATION TO DEMAND

- Add the improved service equipment to the attainable service supply of rehabilitated equipment to get the total available service supply
- If the total available service supply exceeds the service demand, measures should be taken to benefit from the surplus service supply.
- If the service demand is not met by the total available supply, the deficiency can be covered through various alternatives such as increasing the equipment working hours, hiring service and/or equipment from the private sector, or purchase of equipment. Factors affecting the corrective actions to be taken are discussed in Chapter 6.

ASSURANCE OF HIGH EQUIPMENT UTILIZATION AND SERVICE SUPPLY

High values of equipment utilization and service supply can be realized only when the capacity of the operation and maintenance system copes with the demands of all equipment, whether available or to be purchased. Calculation of these demands is presented in Chapter 4.

Chapter 4

Assessing Operation and Maintenance Demand

Planned service supply can not be achieved without the proper support from an operation and maintenance system. In addition to good management, all elements of the O&M system should meet accepted standards in order to guarantee high equipment utilization and service supply.

Operation and maintenance elements are known to be

I. Manpower
   - Manpower for maintenance
   - Manpower for operation
   - Training of manpower

II. Maintenance Center Area

III. Tools and Machine Tools

IV. Spare parts and Stores

V. Financing

Service demand of each of these elements depends on the types and number of equipment concerned. Calculate the service demand for each element that covers the needs of existing equipment first. Then calculate the O&M service demands of additional equipment. The guidelines for these calculations are presented in what follows.

CALCULATION OF DEMAND FOR O&M ELEMENTS

Norms for determining demand for O&M elements are found in Appendix B. Procedures to be followed are presented in the following:

I. MANPOWER

Enough manpower should be recruited to guarantee proper operation and maintenance of equipment. Training to upgrade the skills of all personnel involved in the O&M system should be conducted continuously.

Manpower for Maintenance

To calculate demand for manpower for maintenance, covering both present and future equipment needs, use Tables 4.1.a and 4.1.b, respectively.

- Enter in Table 4.1 a all the equipment in conditions 4 and 3, as well as equipment in conditions 2 and 1 that will be rehabilitated . Equipment should be entered by category, e.g. road construction equipment, equipped trucks, trucks, tractors,...etc.

- Enter the total number of vehicles in each category, and the recommended number served by one mechanic.

Number of Mechanics

- Determine the number of mechanics required for each category of equipment by dividing the total number of vehicles by the recommended number served by one mechanic. Whenever the result contains a fraction, round it to the higher integer. Enter this number in Column C.

- Find the total calculated number of mechanics by adding the numbers in column C, *calculated number of mechanics*, together.

- Increase the total calculated number of mechanics to account for their work efficiency. Assuming a mechanic's efficiency equal to 70 percent, the total modified number of mechanics equals the calculated one divided by 0.7.

- Distribute the resulting modified total number among the different types of equipment.

Total Technical Staff

- Determine the number of electricians required (10 percent of the mechanics) and the number of mechanical and electrical foremen (5 percent of

mechanics and electricians respectively). Round up any resulting number to the higher integer, if it contains a fraction, and write the obtained results in the appropriate column.

- Sum the total modified number of mechanics, total number of electricians, and total number of foremen to get the total number of technical staff.

Helpers

- Calculate the number of helpers (25 percent of the technical staff). Round up the resulting number and enter the result in the last column.

Administrative Staff

- Calculate the number of required administrative staff as 5 percent of the total number of technical staff. Round up the resulting number to the higher integer if it contains a fraction.

Storekeepers

- To determine the number of storekeepers, find the total number of pieces of equipment and divide by 50 to get one storekeeper for every 50 pieces.

Others

- Determine the required number of other workers needed for such activities as welding, fitting, painting, turning,...etc.

For servicing additional future equipment, as found in Chapter 3, determine the needed manpower in the same manner, using Table 4.1.b.

Table 4.1.a Demand Manpower For Maintenance of Present Equipment

No.	Present Equipment Types	No. of A	No. of Equipment served by one mechanic B	No. of Mech. Calculated C=A/B	No. of Mech. Modified D	No. of Elect. E	No. of Mech. Formen F	No. of Elect. Formen G	Total Tech. Staff D+E+F+G	No. of Helpers
1										
2										
3										
4										
5										
6										
Total										

Administrative Staff (5% of Tech. Staff)	Storekeepers (1 per 50 veh.)	Others

Table 4.1.b Demand Manpower For Maintenance of Future Equipment

No.	Future Equipment Types	No. of A	No. of Equipment served by one mechanic B	No. of Mech. Calculated C=A/B	No. of Mech. Modified D	No. of Elect. E	No. of Mech. Formen F	No. of Elect. Formen G	Total Tech. Staff D+E+F+G	No. of Helpers
1										
2										
3										
4										
5										
6										
Total										

Administrative Staff (5% of Tech. Staff)		Storekeepers (1 per 50 veh.)		Others

Manpower for OPERATION

Needed manpower for operation of present and future equipment can be determined with the aid of Tables 4.2.a and 4.2.b.

- Enter in the first column of Table 4.2.a each type of equipment and in the second column the quantity of each type.

Drivers

- For each vehicle, one driver and the appropriate number of helpers for its type and capacity are needed. Enter the number of drivers for each type of vehicle in the third column and the number of helpers for each vehicle of that type in the fourth column. This number should reflect the need to maximize the service supply of the equipment.

- Add the column of drivers and enter the total at the bottom of the column.

Helpers

- Multiply the number of helpers for each type and capacity of vehicle by the number of vehicles to get the total number of helpers. Enter this number in the last column and find the total.

- To take into consideration work efficiency and local conditions, increase the number of helpers by at least 10 percent. Thus the required total number of helpers is evaluated as 110 percent of the number obtained in the previous step.

Using the future equipment listed in Table 4.1.b, find its manpower in the same way, using Table 4.2.b.

Table 4.2.a Demand Manpower For Operation of Present Equipment

Present Equipment Type & Capacity	No. of A	Required Drivers A	Required Helpers Per Piece B	Total Helpers Per Equipment Type AxB
Total				

Table 4.2.b Demand Manpower For Operation of Future Equipment

Future Equipment Type & Capacity	No. of A	Required Drivers A	Required Helpers Per Piece B	Total Helpers Per Equipment Type AxB
Total				

Training

For upgrading the skills of the personnel involved in the O&M activity, a training policy should be developed. The funds for training should be made available, and can be evaluated using Table 4.3, for present and future manpower.

- Enter the expected training cost per head per year for each category of trainees in Table 4.3.
- Using the figures in Tables 4.2.a and 4.2.b, fill in the number of personnel in each category for both present and future equipment operation.
- Multiply the cost per head by the number of staff to calculate the training cost for both present and future operation.
- Sum each cost column and enter the total.

Table 4.3 Training Costs in Present and Future

Staff	Training Cost Per Head Per Year (LE) A	Present Needs		Future Needs	
		No.Staff B	Training Cost AxB	No. Staff C	Training Cost AxC
Engineers					
Technicians (mech, elect, foremen)					
Administrative (including Store-keepers)					
Drivers					
Others					
Total					

II. MAINTENANCE CENTER AREA

Using Table 4.4, calculate the required building area to meet present and future needs.

- List equipment types and minimum building area per mechanic for each type as found in Appendix B.
- Enter the number of mechanics needed for each type of both current and additional equipment from Tables 4.1a and 4.1b.
- Calculate building area for each equipment type by multiplying the number of mechanics by the area per mechanic. Sum the areas to get the total work space.

Multiply the building areas for present and future needs by 2 to get the area of the maintenance center needed in each case.

Table 4.4 Maintenance Center Buildings Area

Equipment Category	Minimum Work Space Per Mechanic (m2) A	Present Needs		Future Needs		
		No. of Mechanics B	Work Area (m2) C=A x B	Additional No. of Mechanics D	Additional Work Area (m2) E=A x D	Total Work Space (m2) C+E
Total						

III. TOOLS AND MACHINE TOOLS

- To find the required number of standard tool boxes to meet the present and future equipment needs, use the total number of technicians on forms 4.1a and 4.1b. Machine tools and other special tools should be available in the workshop according to the type of equipment being maintained.

IV. SPARE PARTS AND STORES

- Calculate the value of the spare parts to be made available through a central warehouse at 10 to 20 percent of the total value of the present and the future equipment. The maintenance store should include spare parts equaling about 5 percent of present and future equipment value.

- The required store area for spare parts depends on the type and category of present and added equipment as found in the equipment assessment and the information presented in Appendix B. Using Table 4.5, enter the types of equipment and the required space for each type. Enter the quantity of each type of equipment and multiply it by the m^2 per piece for its type. Enter both present and added equipment.

Table 4.5 Workshop Space and Buildings

Equipment Category	Minimum Store Area Per Piece (m^2) A	Present Needs		Future Needs		
		No. of Equipment B	Min. Store Area Per Category (m^2) C = A x B	Additional No. of Equip. D	Min. Required Additional Area (m^2) E = A x D	Total Store Area (m^2) C + E
Total						

V. FINANCING

Funding must cover the costs of operation and maintenance demand. These costs include manpower, consumable materials, tools and capital costs such as area expansion, stores, and machines.

Manpower and Capital Funds

Manpower costs are covered from Bab I, the capital costs from Bab III. Demand for funds from Bab I and Bab III can be estimated using the number of required personnel and their incentives, building extensions, working area extensions, and the needed extra machines. These costs vary from one governorate to another in view of the salary scale and extensions costs pertinent to each governorate.

Operation and Maintenance Funds

Demand for Bab II funds to cover operation and maintenance running costs depend on the costs of the materials to be used, fuels and lubricants, maintenance invoices paid to others for equipment service and repair, machining of parts at other maintenance centers, and hired transportation. This is in addition to the costs of personnel training, electric power, water supplies, and stationery.

Material

Materials include, beside the spare parts, the cleaning and washing materials, welding wires and gaskets, rags, and papers and should be determined by the work volume.

Fuel/lubricants

Fuel and lubricant costs can be calculated as shown in Appendix C.

Hired Services

Costs paid to others (e.g. equipment dealers) to carry out equipment maintenance, parts repair or change, and to hire transportation equipment should be calculated giving consideration to local conditions.

Total

The total sum of all these items presents the demand for funds to be covered from Bab II.

Chapter 5

Determining O&M Supply

The supply of the operation and maintenance system should at least cover the demand of the presently available equipment, whether operational or to be rehabilitated. If more equipment is to be purchased in the future, the O&M system supply also should cover the demand of this equipment.

The present supply of the O&M system elements can be calculated as explained here. The figures will be compared with the demand capacities, as determined in Chapter 4, to find deficiencies and determine the funds needed to overcome them.

AVAILABLE CAPACITIES OF O&M ELEMENTS

The following procedures provide the methods for determining the available capacity of each element in the O&M system.

MANPOWER

- Determine the available manpower of the O&M system by physically taking a head count, or obtaining the data from the personnel department. This includes the drivers, drivers' helpers, administration staff, mechanics, electricians, helpers, foremen, maintenance administrative staff, and storekeepers.
- Determine the available funds for training from records in the training department, or from Bab II.

MAINTENANCE CENTER AREA

- Determine the total area of the maintenance center and the area of the buildings by physically measuring or from available building drawings.

TOOLS AND MACHINE TOOLS

- Count the available complete tool boxes, special tools, machine tools and equipment.

SPARE PARTS AND STORES

- Determine the available spare parts in the central warehouse and maintenance centers from the available records or by physically checking. Determine the current value of these spares with the aid of the available records or through a field survey of dealers, agencies, or distributors.
- Determine the available store area by physically measuring or from building drawings.

FINANCING

- From Bab I, Bab II and Bab III, find the funds available for the different elements of the O&M system.

COMPARISON BETWEEN CURRENT O&M DEMAND AND SUPPLY

Compare the present supply of each element of the O&M system with the present demand for each element to find the shortages. Present element demand is the capacity required to cover the needs of the presently available equipment. Use Table 5.1 to make the comparison.

PRESENT SUPPLY VS PRESENT DEMAND

- Enter the present demand and available supply capacities of each element in Table 5.1.
- Elements not needed, such as some types of machines and equipment, are to be ignored, and needed elements not included in the table are to be entered under *others*.
- Present excess capacities or shortages of the elements can then be found. Total costs required to cover shortages can be found by estimating costs of increasing an element capacity by one unit and multiplying this cost by the total shortage in capacity.
- Shortages in the O&M system financing through Bab I, Bab II and Bab III can thus be found from the results present at Table 5.1. These shortages must be covered as soon as possible, since this is a condition for the high productivity and utilization of the presently available equipment.

Table 5.1 Shortage Implements Capacity & Costs of Remedy

No.	Elements and Unit	Demand Element Capacity A	Presently Available Element Capacity B	Element Shortage Capacity C = A - B	Cost Per Unit of Shortage (LE) D	Total Cost to Cover Shortage (LE) C x D	Source of Finance (Bab)
1	**Manpower & Training**						I
1.1	Driver						I
1.2	Driver Helper						I
1.3	Mechanic						I
1.4	Electrician						I
1.5	Mech. Forman						I
1.6	Elect. Forman						I
1.7	Maint. Helper						I
1.8	Administrator						I
1.9	Storekeeper						I
1.10	Others						I
1.11	Training Costs(LE)						II
2	**Area of Maintenance Center**						
2.1	Buildings area (m2)						III
2.2	Total area (m2)						III
3	**Tools and Machines**						
3.1	Tool Boxes for Mech.						II
3.2	Tool Boxes for Elect.						II
3.3	Special Tools Costs (LE)						II
3.4	Other Tools						II
3.5	Equipment and Machines						
	Air Compressor						III
	Fuel Ingection Pump Tester						III
	Barke System Air Bleeder						III
	Water System Tester						III
	Hydraulic Pressure Gauges						III
	Accumulator Charging Unit						III
	Hydraulic Jacks						III
	Mobile Hydraulic Jack						III
	Cranes						III
	Transfer Equipment						III
	Measuring Instruments						III
	Lathe						III
	Drilling Machine						III
	Hand Grinders						III
	Hydraulic Press						III
	Hand Greaser						III
	Battery Charger						III

Table 5.1 Shortage Implements Capacity & Costs of Remedy
(CONT.)

No.	Elements and Unit	Demand Element Capacity A	Presently Available Element Capacity B	Element Shortage Capacity C = A - B	Cost Per Unit of Shortage (LE) D	Total Cost to Cover Shortage (LE) C x D	Source of Finance (Bab)
	Electric Measuring Instruments						III
	Starter & Dynamo Tester						III
	Welding Equipment						III
	Electric Welding Machine						III
	Electric Hand Shear						III
	Tyres Repair Machines						III
	Tyres Balancing M/C						III
	Dismantling & Assembling						III
	Unit for Tyres						III
	Tyre Angle Adjustment Equipment						III
	Work Benches, Furniture, ...etc						II
	Others (give details in what follows)						
4	**Spare Parts & Stores**						
4.1	Spare Parts Value (LE)						II
4.2	Stores Area (m2)						III
4.3	Stores Furniture Value (LE)						II
5	**Funds for O&M Performance**						
5.1	Raw Materials						II
5.2	Fuels and Lubricants						II
5.3	Other						

COMPARISON BETWEEN O&M FUTURE DEMAND AND CURRENT SUPPLY

Knowing the O&M demand of future equipment, as determined in Chapter 4, and the available excess or shortage in the O&M element capacities, as found in Table 5.1, the required increase in the O&M element capacities to meet present and future equipment can be calculated using Table 5.2.

- A total excess element capacity in Table 5.2 takes place if the present excess capacity of the element exceeds the demand for future equipment.

- A total shortage in an element capacity takes place when:

    - A present excess capacity prevails, but it is less than the demand capacity for future equipment. In this case the total shortage in element capacity is the difference between the two figures.

    - A present shortage in the element capacity is found. In this case the total shortage in the element capacity is the sum of the present shortage and the demand capacity for future equipment.

The capacity of the elements suffering shortage in capacity should be increased to overcome all the shortages, if more equipment is to be purchased in future. Failure to increase any element capacity to the required level, for financial or other reasons, implies that buying more equipment in future will not lead to the sought service supply, and hence should not be allowed. Other means of service provision to the zone should thus be adopted.

Table 5.2 Excess or Shortage Capacities for Future and Present Equipment

No.	Elements and Unit	Demand Capacity for future Equipment A	Present Excess Capacity B	Present Shortage Capacity C	Total Excess Capacity B - A	Total Shortage Capacity D = A + C	Cost Per Unit of Shortage (LE) E	Total Cost to Cover Shortage (LE) D x E	Source of Finance (Bab)
1	**Manpower & Training**								I
1.1	Driver								I
1.2	Driver Helper								I
1.3	Mechanic								I
1.4	Electrician								I
1.5	Mech. Forman								I
1.6	Elect. Forman								I
1.7	Maint. Helper								I
1.8	Administrator								I
1.9	Storekeeper								I
1.10	Others								I
1.11	Training Costs(LE)								II
2	**Area of Maintenance Center**								
2.1	Buildings area (m2)								III
2.2	Total area (m2)								III
3	**Tools and Machines**								
3.1	Tool Boxes for Mech.								II
3.2	Tool Boxes for Elect.								II
3.3	Special Tools Costs (LE)								II
3.4	Other Tools								II
3.5	Equipment and Machines								
	Air Compressor								III
	Fuel Ingection Pump Tester								III
	Barke System Air Bleeder								III
	Water System Tester								III
	Hydraulic Pressure Gauges								III
	Accumulator Charging Unit								III
	Hydraulic Jacks								III
	Mobile Hydraulic Jack								III
	Cranes								III
	Transfer Equipment								III
	Measuring Instruments								III
	Lathe								III
	Drilling Machine								III
	Hand Grinders								III
	Hydraulic Press								III
	Hand Greaser								III
	Battery Charger								III

Table 5.2 Excess or Shortage Capacities for Future and Present Equipment (CONT.)

No.	Elements and Unit	Demand Capacity for future Equipment A	Present Excess Capacity B	Present Shortage Capacity C	Total Excess Capacity B - A	Total Shortage Capacity D = A + C	Cost Per Unit of Shortage (LE) E	Total Cost to Cover Shortage (LE) D x E	Source of Finance (Bab)
	Electric Measuring Instruments								III
	Starter & Dynamo Tester								III
	Welding Equipment								III
	Electric Welding Machine								III
	Electric Hand Shear								III
	Tyres Repair Machines								III
	Tyres Balancing M/C								III
	Dismantling & Assembling								III
	Unit for Tyres								III
	Tyre Angle Adjustment Equipment								III
	Work Benches, Furniture, ...etc								II
	Others (give details in what follows)								
4	**Spare Parts & Stores**								
4.1	Spare Parts Value (LE)								II
4.2	Stores Area (m2)								III
4.3	Stores Furniture Value (LE)								II
5	**Funds for O&M Performance**								
5.1	Raw Materials								II
5.2	Fuels and Lubricants								II
5.3	Other								

Chapter 6

Need Assessment Results and Decision Guide

Analysis and comparison of demand and supply reveal the needs of the rolling stock service systems. Both the service of the vehicles and the O&M system that allows them to perform satisfactorily must be considered. The deficiencies or excess in equipment and O&M supply that are revealed during this process constitute the needs assessment.

The following summarizes the need assessment procedures and guides the use of the obtained results in making decisions that lead to covering the demand for service and full utilization of equipment.

ROLLING STOCK NEED ASSESSMENT PROCEDURES

Procedures to be followed for need assessment are summarized in the following:

DEMAND

- Determine the service demand as calculated in chapter 2.

EXISTING SUPPLY

- Determine the values of the operational equipment existing service supply, possible service supply, and the ratio (X) between these supplies, as shown in Chapter 3.
- Determine the equipment percentage utilization (U) as shown also in Chapter 3, as well as the ratio X/U.

IMPROVING EXISTING SUPPLY

- The calculated values of X, U, and X/U shall enable you to decide whether interventions are needed to improve the service supply of equipment or not, as follows

NO INTERVENTIONS NEEDED

- If the values of both X and U are high, while X/U is higher than 0.95, the O&M system would evidently be proper and does not need interventions. The existing service supply in this case would be at a maximum value and can not be sensibly increased.

PROBLEMS IN OPERATION

- If the U is high, but the value of X is low, problems in operation are encountered. This applies as well when the ratio between X and U, is less than 95%. In these cases the following areas must be studied for possible interventions:

Equipment Use

Equipment might be have been used for purposes other than that for which it was purchased. This can be seen from equipment information forms; namely Tables 3.1 and 3.2. Equipment usage, assigned in these tables as *other tasks*, should be eliminated or at least minimized.

Skilled Operators

The number of drivers and assistants might not be enough for the equipment. Such a shortage would be apparent from Table 5.1, and should be covered by budgeting for and recruiting more staff. Training to upgrade operator skills should be carried out continuously according to a training plan. The increase of funds required for this training can be found from Table 5.1 and should be made available through Bab II, or other sources.

Incentives

Without a proper system of incentives and overtime, equipment service supply can not be increased. Such a system should be designed to include all the staff at the various levels, and yield adequate merits for them on the basis of their productivity. Sources of funding this system should be available through Bab I or through local investments projects.

Balanced Work Systems

Reduced service supply might result from an imbalance in the work systems. For instance, if the number of assistants accompanying a refuse truck is fewer than needed, the truck will take longer than expected to be loaded. If workers bringing solid waste from different locations to the main collection point do not finish their task before the truck arrives, the refuse truck will stand idle until this work is finished. The trip time is thus increased and the service supply reduced. Through proper planning and management, balance among the different groups can be achieved to increase productivity.

System Management

Improper management of operation results in reduced service supply. This includes failure to provide a fair system of incentives and overtime compensation for all personnel, allocating inexperienced personnel to equipment, allocating vehicles with inadequate capacity for the service demanded or the condition of the roads where they work, or an inadequate recording system. All of these constraints should be overcome through proper management.

MAINTENANCE PROBLEMS

- A low percentage utilization U may indicate problems in maintenance. Maintenance and repair problems would be the reason if equipment needing maintenance remains idle for more than the planned period. This can be seen from Tables 3.1 and 3.2. In this case the following areas are to be investigated for possible interventions:

Spare Parts

Enough spare parts of appropriate types might not be available. A spare parts stocking policy should be developed taking into account local conditions. The policy should include use of the private sector. Required funds increase should be made available in Bab II, as would be apparent in Table 5.1.

Workshop Capacity

A shortage in skilled maintenance and repair staff, training, tools, machines, or work space reduces the efficiency of the maintenance system.

To correct the shortage, use the budget available to cover shortages and survey the capacity of the public and private sector workshops in the zone, in order to save some capital costs.

Incentives

Incentives for workshop personnel, as the incentives for operators, are necessary to encourage increased productivity.

Workshop Management

Management needs of the workshop are similar to those of operation management. Proper assignment of responsibility, training of personnel, adequate tools and space, and good record keeping are essential to the service capacity of a workshop.

Standardized Equipment

A non-standardized fleet puts heavy pressure on spare parts stocks, number of skilled technicians required, and management. Care should be taken during equipment purchase to keep the fleet standardized. To standardize the current fleet, formulate a policy of equipment exchange among marakez and dispose of nonoperational equipment that is different from the standard fleet through selling or hiring.

WORK ORDERS

- If U is low, while the equipment is not technically defective or under service for more the planned period, the reason might be lack of work orders for this type of equipment. This can be seen in Table 3.1, and implies either that more equipment is available with respect to demand or that this type of equipment is not adequate to supply the service in the zone. Look for a remedy through equipment exchange.

IMPROVED SERVICE SUPPLY

- When corrective actions are taken, both equipment utilization and existing service supply shall increase. An improve in the service supply of the currently operational equipment will be gained. The resulting improved supply can be calculated as shown in Chapter 3.

IMPROVED SERVICE SUPPLY VS DEMAND

- Compare the service demand (SD) with the improved service supply (ISS). If SD is less than ISS, no more equipment is needed. Make maximum use of excess operational and nonoperational equipment. If SD nearly equals ISS, no more equipment is needed. In this case make maximum use of nonoperational equipment.

- The elements of the O&M system in this case should be of enough capacity to cover the presently operational equipment needs, as calculated in Chapter 4. Any shortages, that would be apparent in Table 5.1 should be covered after making the necessary funds available in Bab I, Bab II, and Bab III.

TOTAL AVAILABLE SUPPLY VS DEMAND

- If service demand is more than improved service supply of operational equipment, determine the total attainable service supply of rehabilitable equipment as shown in Chapter 3, and add to it the improved service supply of operational equipment to get the total available service supply.

- Compare the service demand with the total available service supply. In case the total available service supply is more than service demand, make beneficial use of the available excess service supply.

- The elements of the O&M system in this case should be of enough capacity to cover the needs of the presently operational equipment as well as the needs of the equipment that shall be rehabilitated, as calculated in Chapter 4. Shortages in the elements capacities, as would be indicated in Table 5.1, should be covered.

- If the service demand exceeds the total available service supply, measures should be taken to cover this shortage through service hiring or other means.

RECOMMENDATIONS

WHEN SERVICE SUPPLY EXCEEDS DEMAND

In case that the improved service supply or the total available supply exceeds the service demand, measures should be taken to benefit from the surplus service supply. Some of the alternatives are:

- Offer basic services to other marakez that are deficient in service supply, using agreed upon rates, or redistribute equipment.

- Develop a recovery scheme project (Investment Project) to make the surplus service supply available to others, and use a portion of the profit for improving the operation and maintenance environment.

- Review the governorate plans in order to increase the service demand from rolling stock to approach the service supply. This would help reduce investments in new governorate projects for basic service provision by means other than rolling stock.

- Sell, rent, or redistribute equipment

RECOMMENDATIONS

WHEN TOTAL AVAILABLE SERVICE SUPPLY DOES NOT MEET DEMAND

If the total available service supply from operational and rehabilitated equipment is found to be less than the service demand, the resulting deficiency can be covered through one or some of the following alternatives:

Increase Working Hours

Increase the working hours per day of some or all of the available equipment to increase its service supply. If the working hours are increased by about three hours a day, the same number of operators would be required.

Incentives

Provide adequate incentives and overtime pay to operators involved in this solution.

Increased O&M

The demand of some of the O&M elements as dictated by the available equipment and calculated in Chapter 4 will increase by a value that depends on the increase of the working hours and type of equipment involved.

Hire Service From Others

Develop a policy to encourage the private sector to extend its activity in the governorate to provide basic service or to increase its supply of basic service. Make contracts with the private sector that include clear identification of responsibilities.

Hire Equipment

Make contracts with companies that offer appropriate services.

Purchase Equipment

After the shortage in service supply has been calculated, and some of it partially covered by the above mentioned interventions, calculate the remaining shortage and cover it through equipment purchase.

When determining the types and number of equipment to be purchased, consider factors such as:

- Conditions at the location where the equipment would work (environmental impacts, roads conditions, maneuvering capabilities)
- Equipment standardization
- Equipment initial cost and operating expense

Equipment purchase would be contingent on covering shortages in the O&M elements capacities, as shown in Table 5.2.

Shortages in form of the maintenance capabilities, as would be found in either Table 5.1 or 5.2 might be partially covered by contracting with qualified private or public sector workshops active in the zone. Contracts for maintenance and repair of equipment and machining of some parts can complement the markaz workshop capacity.

REPORTING NEED ASSESSMENT RESULTS

Results obtained from applying these guidelines at the various marakez should be presented to high officials and decision makers in the governorate to help them make decisions that guarantee coverage of the service demand, as follows:

- Each markaz should submit a report to the governorate maintenance coordinator, that includes the following for each basic service:-

  - The available rolling stock in the markaz and the action recommended for standardizing the fleet.

  - The service demand

  - Analysis of the service supply by the operational rolling stock, including the percentage utilization (U) and the value of (X) for each piece of equipment, reasons for any low values of U, X or X/U and proposals for remedy, the expected improved service supply by operational equipment, the nonoperational equipment that should be disposed, equipment to be rehabilitated, costs of rehabilitating the equipment, and the surplus or deficiency in service supply.

  - Recommendations to get beneficial use of the surplus service supply or to cover the shortage of service supply in view of the local conditions.

  - The status of the capacities of the O&M elements and any needed increase in the capacity of O&M elements that are short, together with the funds required.

- The maintenance coordinator, having the reports from the different Marakez, should summarize the results and investigate the various marakez recommendations in view of the laws and regulations, as well as the possibility of practical implementation. He should then report his findings regarding the Marakez recommendations, together with his own recommendations, to the high officials and decision makers in the governorate to help them to take the adequate decisions.

- Marakez engineers should include in the quarterly report information about rolling stock performance during each three months. This information should include the value of equipment percentage utilization U, the supplied service and the possible one, the value of X which is the ratio between these two supplies, as well as the value of X/U. Such information can be included in the quarterly report by attaching Table 3.12, after being dully filled, to the quarterly report. Maintenance coordinator can thus investigate the equipment performance criteria, and report his findings and recommendations to the Governorate Local Development Committee (GLDC) to follow up equipment utilization and productivity and take the right decisions in the right time.

APPENDIX A

APPENDIX A
GUIDELINES FOR DETERMINING DEMAND FOR O&M ELEMENTS

MANPOWER

The number of equipment operators as well as the technical and administrative staff for maintenance and repair work depends on the types and number of equipment dealt with. The following guidelines help you to determine the type and number of personnel.

Drivers

The number of drivers should be at least equal to the number of vehicles.

Helpers

The number of helpers for each driver depends primarily on the equipment type. For a refuse compactor truck, for instance, four helpers should be available, while for a loader no helpers may be needed.

Mechanics

The number of mechanics required for repair and maintenance work depends on the equipment type and number. A guide for estimating the minimum number of mechanics is as follows:

Road construction/ earth moving equipment	1 mechanic per 5 pieces of heavy equipment
Equipped trucks (refuse trucks, sewage trucks, etc)	1 mechanic per 8 vehicles
Trucks (over 5 ton)	1 mechanic per 10 vehicles
Tractors	1 mechanic per 12 vehicles
Light vehicles (cars, pick ups, microbuses, etc)	1 mechanic per 15 vehicles
Other equipment (motor cycles, generators, water pumps, etc)	1 mechanic per 20 pieces of equipment

Electricians

The number of electricians required is 10 percent of the number of mechanics.

Foremen

The number of mechanical foremen is 5 percent of the number of mechanics, and that of electrical foremen is 5 percent of the electricians.

Mechanics' Helpers

The number of mechanics' helpers should be about 25 percent of the number of mechanics.

Technical Staff The total number of technical staff required is thus the sum of numbers obtained in steps from 3 to 6.

Administrative Staff The number of administrative staff required for the workshop is about 5 percent of the total number of technical staff.

Storekeepers The number of storekeepers depends on the number of equipment dealt with. One storekeeper is required for 50 pieces of equipment.

Other Workers Other workers might also be needed for other work performed in markaz maintenance centers, such as turning, welding, fitting, ... etc.

TRAINING

Training to upgrade personnel is considered an essential component of the O&M system. The training programs should be designed for different levels of skill and types of work. The cost of training per year depends on the number of staff and their duties. For instance, during the coming year the training of an engineer would cost about 500 LE, while for a technician it would be about 400 LE. For an administrator it would be 350 LE, for a driver about 300 LE, and for the others about 250 LE per head. In addition to in-house training, it is advisable to have a mobile training facility for conducting training courses in the field to show the maintenance procedures to be followed.

MAINTENANCE CENTER AREA

Workshop space required depends on the amount of equipment and the number of mechanics for each type of equipment. A guide for estimating the area needed for each mechanic is as follows:

Road construction /Earth moving equipment	45m^2/mechanic
Equipped trucks	40 m^2/mechanic
Trucks (over 5 ton)	30 m^2/mechanic
Tractors	35 m^2/mechanic
Light vehicles	20 m^2/mechanic
Other equipment	12 m^2/mechanic

Total area of the maintenance center is twice the area of the buildings.

TOOLS AND MACHINE TOOLS

Enough tool boxes, special tools, as well as machine tools should be available.

Tool Boxes and Special Tools

All maintenance personnel (e.g. mechanics, electricians, welders) should be supplied with tool boxes containing adequate tools to meet the work requirements.

Special tools and service aids must be available from the workshop tool room to supplement the tools available in tool boxes.

Machine Tools

Workshop machine tools and equipment vary according to the type of rolling stock to be maintained, the duties assigned to the workshop, and its capacity. Generally, the following items are recommended to be available:

air compressor	drilling machine
lathes	presses
jacks	paint spraying equipment
pipe bending equipment	benches
bench vices	battery chargers
cleaning equipment	tire service equipment
welding equipment	body repair tools
pullers	

SPARE PARTS

While the value of the spare parts to be available depends upon the value of equipment to be repaired, the types of these spare parts depend primarily on the equipment type and the conditions that determine whether spares are fast moving or slow moving.

Central Warehouse

At a central warehouse the value of spare parts should at least equal 10 percent of the cost of all equipment. This percentage would vary with the usage pattern and the amount of equipment, but should not be more than 20 percent of the total cost of all equipment.

Maintenance Store

At a maintenance store the spare parts value should be about 5 percent of the total cost of all equipment.

SPARE PARTS STORE AREA

The store area for spare parts for each piece of equipment depends on the equipment type, and can be estimated according to the following guidelines:

Road construction/Earth moving	2 m^2/vehicle
Equipped trucks	2 m^2/vehicle
Trucks (over 5 ton)	2 m^2/vehicle
Tractors	1.5 m^2/vehicle
Light vehicles	1 m^2/vehicle

Other equipment	0.75 m^2/piece

FINANCING

Funds should cover the costs of the personnel and equipment required for the O&M system. Bab I should cover manpower wages and incentives. Bab II should cover costs of training, tools, and spare parts as well as equipment runing costs such as fuels, oils and greases. Bab III covers capital investments such as building construction, furniture, machine tools, and storage space.

APPENDIX B

ANALYSIS OF EQUIPMENT UNDERUTILIZATION AND REDUCED SERVICE SUPPLY, AND PROPOSED REMEDIES

Serial No.	Reasons for Underutilization	Remedy
1	**Operational**	
1.1	Unbalanced working system	Properly design the working system especially when more than one system is needed to cover the service
1.2	Equipment Misuse	Follow manufacturer's instructions for the usage of equipment
1.3	Lack of Skilled Operators	1. Recruit the required number of drivers and assistants. 2. Train all personnel involved in operation of equipment to the required level to fulfill their duties. 3. Adopt and enforce strict disciplinary procedures. 4. Assess regularly the performance of personnel and take necessary actions for improving their performance. 5. Look at the present organizational structure and GOE laws and regulations regarding employment and recommend modifications if necessary to allow recruiting and hiring. 6. Adopt a policy for equipment standardization.
1.4	Lack of incentives	1. Develop productivity agreements or improve existing ones. 2.Look at means of improving existing social benefits. 3. Improve working environment. 4. Look at the existing management system and modify within GOE laws and regulations (e.g. adoption of investment projects). 5. Investigate present GOE laws and regulations governing incentives and recommend modifications if necessary.
2	**Service and Repair**	
2.1	Nonavailability of spare parts	1. Develop a proper procurement and store management system.

		2. Assess spare parts availability from equipment dealers (Private and Public). 3. Look at possibility of importing required spare parts which are not available in the local market. 4.Investigate the possibility of scrapping of old equipment unrehabilitable due to unavailability of spares. 5. Adopt a policy for equipment standardization
2.2.	Limited maintenance facilities, tools, equipment, test benches, etc.	1. Improve existing work areas and/or develop new ones to cope with the fleet requirements. 2. Acquire sufficient tools and equipment to carry out adequate maintenance and repair work. 3. Develop and/or improve training facilities. 4. Adopt a policy for equipment standardization.
2.3	Lack of skilled maintenance, service, and repair personnel	Same as in 1.3
2.4	Lack of incentive	Same as in 1.4

The foregoing reasons can thus be primarily attributed to some or all of the following factors:

1. **The weak management structure**
   The existing management structure should be looked at and reorganized in order to achieve efficient utilization of equipment and manpower.

2. **Insufficient financial resources**
   The required funds for proper operation of the equipment and manpower should be determined and compared with available resources.

   In case of deficiencies, look at the possibility of obtaining funds from the central government or from external resources or to offer the service against a reasonable cost.

3. **Non standardization of equipment**
   A standardization policy should be developed and adopted to reduce the operation and maintenance costs.

4. **Lack of proper training**
   Adopt a continuous training policy for all involved personnel.

APPENDIX C

Appendix C

FUELS AND LUBRICANTS COST FOR EQUIPMENT

Calculation of costs of fuels and lubricants for rolling stock concerened with can be carrid out using Table C 1. In this table enter the equipment type and average working hours per equipment per year in the second column. The number of equipment is entered in the third column. The total working hours per year of equipment of the same type can be determined from catalogues, then entered in the fifth column. To estimate the fuel costs, the average fuel consumption per horsepower per hour is to determinned. For equipped vehicles or trucks working outside a city, this is about 0.25 liter/HP/HR, while for those working in a city it is 0.3 liter/HP/HR. For road equipment, the consumption raters vary from 0.25 to 0.3 liter/HP/HR. With the total horsepower and working hours per year known, the total fuel consumption can be calculated, and the total fuel cost determined.

The lubricants costs depend on the number of equipment, number of changes of each lubricant type per year and the needed quantity of lubricant during each change. Knowing these figures, the total quantity needed from each lubricant type can be determined, and the lubricants costs calculated.

The total fuels and lubricants costs can thus be determined.

Table C.1 Fuel and Lubricant Costs

No.	Equipment Types & Average Working Hours Per Year	No. of	Total Working Hours Per Year	Total Power (HP)	Fuel				Lubricants						Fuel & Lubricants Cost (LE)
					Average Consumption Per HP Per Hour (liter)	Total Consumption liter (LE)	Cost Per litre (LE)	Total Cost (LE)	No.	Type	No. of Changes Per Year	Quantity Per Change (litrer)	Cost Per Litre (LE)	Total Cost (LE)	
	A	B	C = A X B	D	E	F = C x D x E	G	H			J	K	L	M = JxKxL	H + M
1									1	Engine Oil	12				
									2	Gear Box Oil	2				
									3	Steering Oil	2				
									4	Hydraulic Oil	2				
									5	Grease	12				
2									1						
									2						
									3						
									4						
									5						
3									1						
									2						
									3						
									4						
									5						
4									1						
									2						
									3						
									4						
									5						
5									1						
									2						
									3						
									4						
									5						
Total Fuel and Lubricants Costs															