Chapter 4

Model Development

To serve the objectives proposed in chapter one , two models are developed as follows:

1. Job Allocation Plan Model

2. Inventory Control Model

4.1 Job Allocation Plan Model

4.1.1 Job Allocation Plan

This model is developed by following **Structure Chart** pattern. All job procedures are separated into seven modules. They are listed as below:

1. Receive customer requirement

2. Identify customer requirement

3. Check facility

4. Open job

5. Operate job

6. Resume job

7. Close job

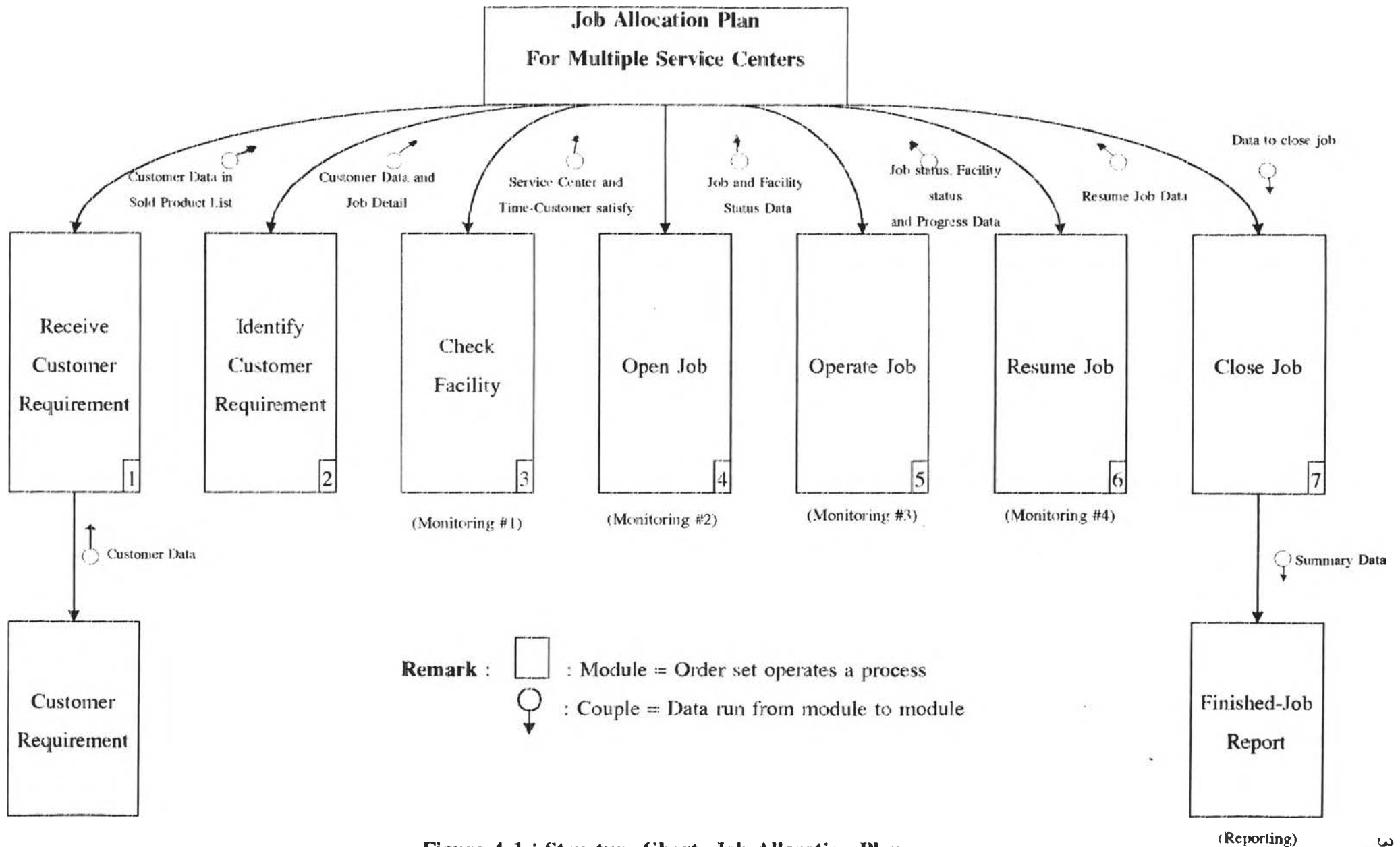All modules will be discussed in the following details

Job Allocation Plan For Multiple Service Centers

Customer Data in Sold Product List

Customer Data, and Job Detail

Service Center and Time-Customer satisfy

Job and Facility Status Data

Job status, Facility status and Progress Data

Resume Job Data

Data to close job

| Receive Customer Requirement 1 | Identify Customer Requirement 2 | Check Facility 3 | Open Job 4 | Operate Job 5 | Resume Job 6 | Close Job 7 |

(Monitoring #1)   (Monitoring #2)   (Monitoring #3)   (Monitoring #4)

Customer Data

Summary Data

Customer Requirement

Finished-Job Report

(Reporting)

Remark : ▢ : Module = Order set operates a process

◯ : Couple = Data run from module to module

Figure 4-1 : Structure Chart -Job Allocation Plan

1. Receive customer requirement

When a customer comes to the company. the administrative officer will input all necessary data: customer name. product name. serial number of the product. job pattern required. service place at service center or customer workplace. contact date. expected start date. service center that customer wants to receive service. Then, the data of customer name and serial number will be brought to check with sold product list. If this customer does not use the product of the company. the program will not accept this requirement and show the status of Can't service to the screen. If this customer name and serial number are in the sold product list. the program will accept this requirement and continue processing in the second module.
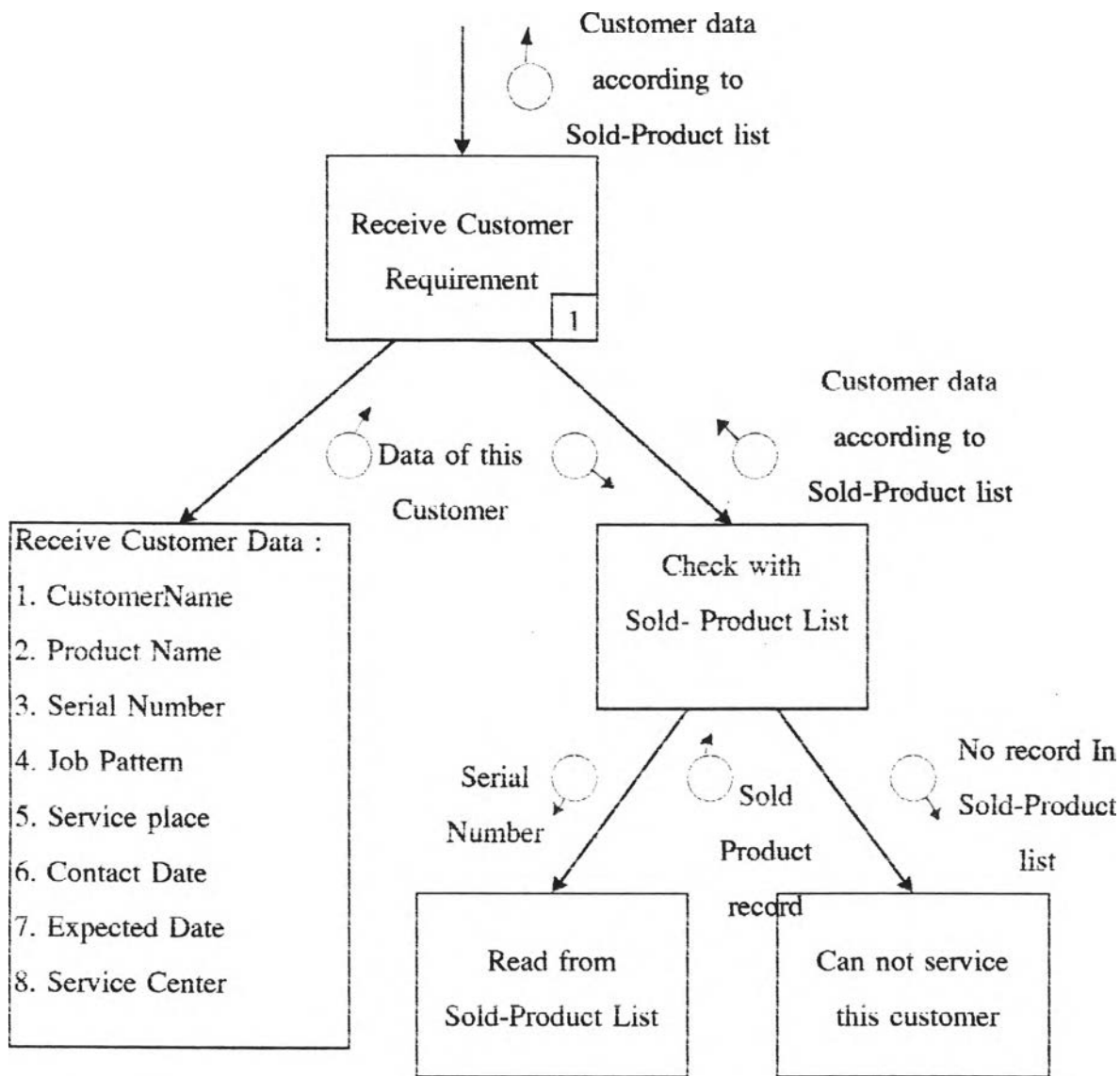
Customer data

according to

Sold-Product list

Receive Customer

Requirement

1

Data of this

Customer

Customer data

according to

Sold-Product list

Receive Customer Data :

1. CustomerName

2. Product Name

3. Serial Number

4. Job Pattern

5. Service place

6. Contact Date

7. Expected Date

8. Service Center

Check with

Sold- Product List

Serial

Number

Sold

Product

record

No record In

Sold-Product

list

Read from

Sold-Product List

Can not service

this customer

Figure 4-2 : Receive Customer Requirement (No.1)

2. Identify customer requirement

The data of job pattern required is brought to check with job pattern list. Normally. incoming job can be classified into two main groups. The first is scheduled job pattern such as **Preventive Maintenance(P.M.)**. This activity the company receives tentative P.M. schedule from sales company. Before this activity is operated. the company must contact customers to make an appointment to service sold product for three or four times within one-year warranty period. The activity may be operated at service centers or customer workplace. It depends on customer requirement. Employees required in terms of quantity and title must be specified before start operation. Mostly. truck-mounted crane product requires one mechanic per job and electrical forklift requires one electrician per job. Sometimes. this activity is operated as a batch at customer workplaces. It means that aftersales department collects the requirement of customers in same or adjacent areas. These customers want the operation in the same interval time. The company. therefore. arrange a program which specifies priority. time to service and traveling route to service these customers.

The second is unplanned pattern. The requirement of this pattern is at once or can be known in advance only a few days. The company. consequently. must manage a schedule to match timing of these requirements. The service patterns in this group are **installation** and **break down maintenance.**

Installation pattern is a standard job pattern. This pattern is always operated in the bay because it uses crane-equipment to lift crane-product to install into the truck. From discussion with engineering department. it can be classified into five patterns. All of them can define job details. quantity and type of employees used. time used for each step. The details of standard installation pattern are shown in appendix section.

Break down maintenance is non-standard job pattern. It is different in each job order. When the requirement of this pattern comes to the company, foreman will decide what facilities such as time, bay, quantity and type of employees used, service place to service this job pattern.

The outcome of this module is facilities and time used to service incoming job. It is the input to check the availability of facilities in the next module.
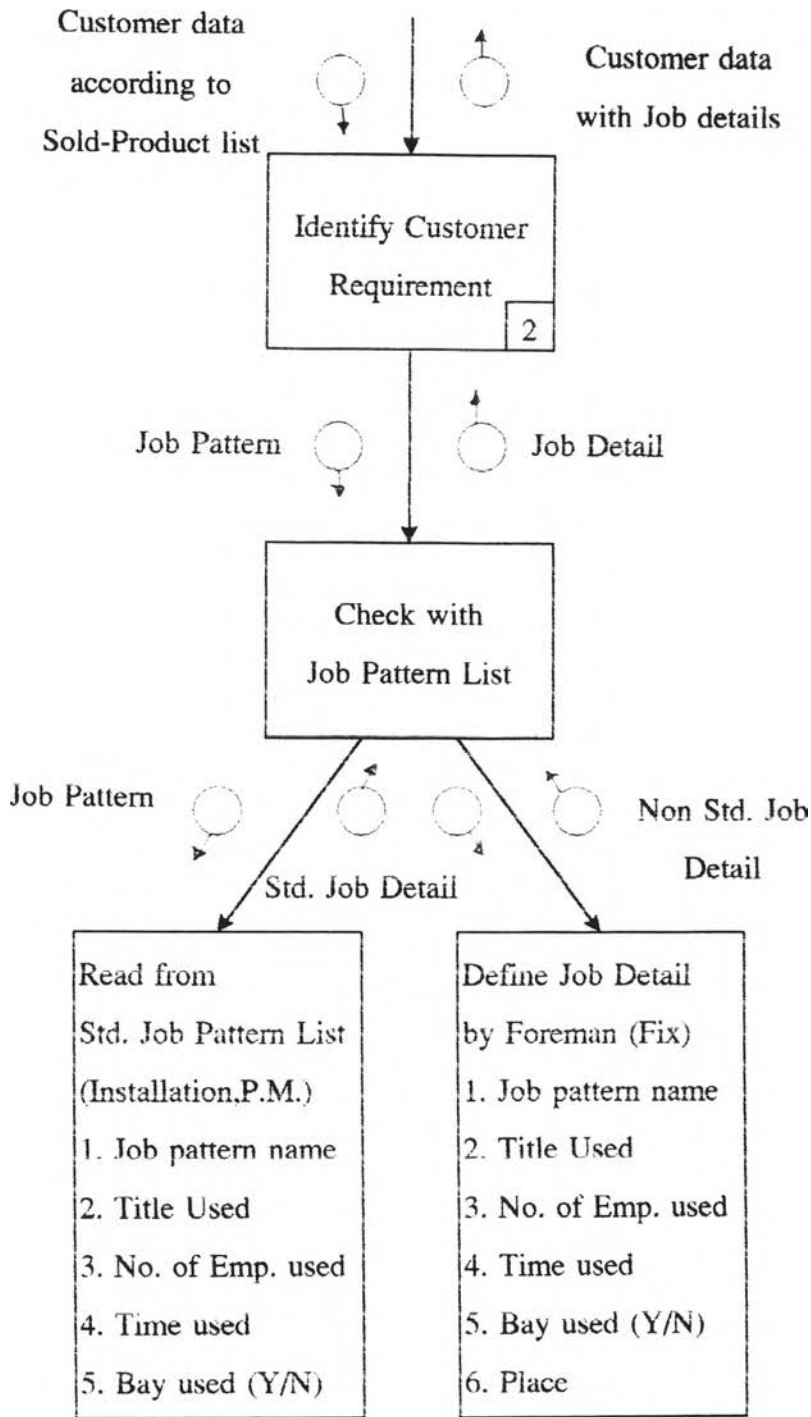
Customer data
according to
Sold-Product list

Customer data
with Job details

Identify Customer
Requirement

2

Job Pattern

Job Detail

Check with
Job Pattern List

Job Pattern

Non Std. Job
Detail

Std. Job Detail

Read from
Std. Job Pattern List
(Installation,P.M.)
1. Job pattern name
2. Title Used
3. No. of Emp. used
4. Time used
5. Bay used (Y/N)

Define Job Detail
by Foreman (Fix)
1. Job pattern name
2. Title Used
3. No. of Emp. used
4. Time used
5. Bay used (Y/N)
6. Place

Figure 4-3 : Identify Customer Requirement (No.2)

3. Check facility

This module is to check the available of facilities and propose the alternatives for customer to make decision to receive service from what service center. The program will bring the output of the previous module to check with the schedule of required facilities. Incoming facilities required are assigned to match facilities schedule based on **First Come, First Served** basis.

If schedule of facilities required is available at the time customer required, The **Reserved** status is marked to facilities status and job status. This case the customer can receive service from the center and at the time they required. If the schedule of facilities required is not available at the time customer required but available in the later time, this case the program will keep the record and continue checking with other service centers. If facilities schedule of other service centers are available at once or available before facilities of the first service center, this alternative are kept to propose the customer for decision making.

At present time, the customer in this situation has three alternatives to make decision. First, the customer may wait to get service from the first service center according to queue order. Second, the customer may be serviced immediately or wait for shorter time and be serviced from the facilities of proposed center. Last choice, the customer may cancel service requirement of that time.

The result of customer decision is brought to record status for reporting and monitoring. If the customer decide to receive service, the **Reserved** status is marked to this job request and required facilities at the time they are available. But if the customer decide to cancel this requirement, **Cancel** status is marked to this requirement. The latter case is focused to find out the cause and recorded in monitoring system.

After the customer have made decision, Job No., job status, facilities status and time used are additionally recorded to the requirement.
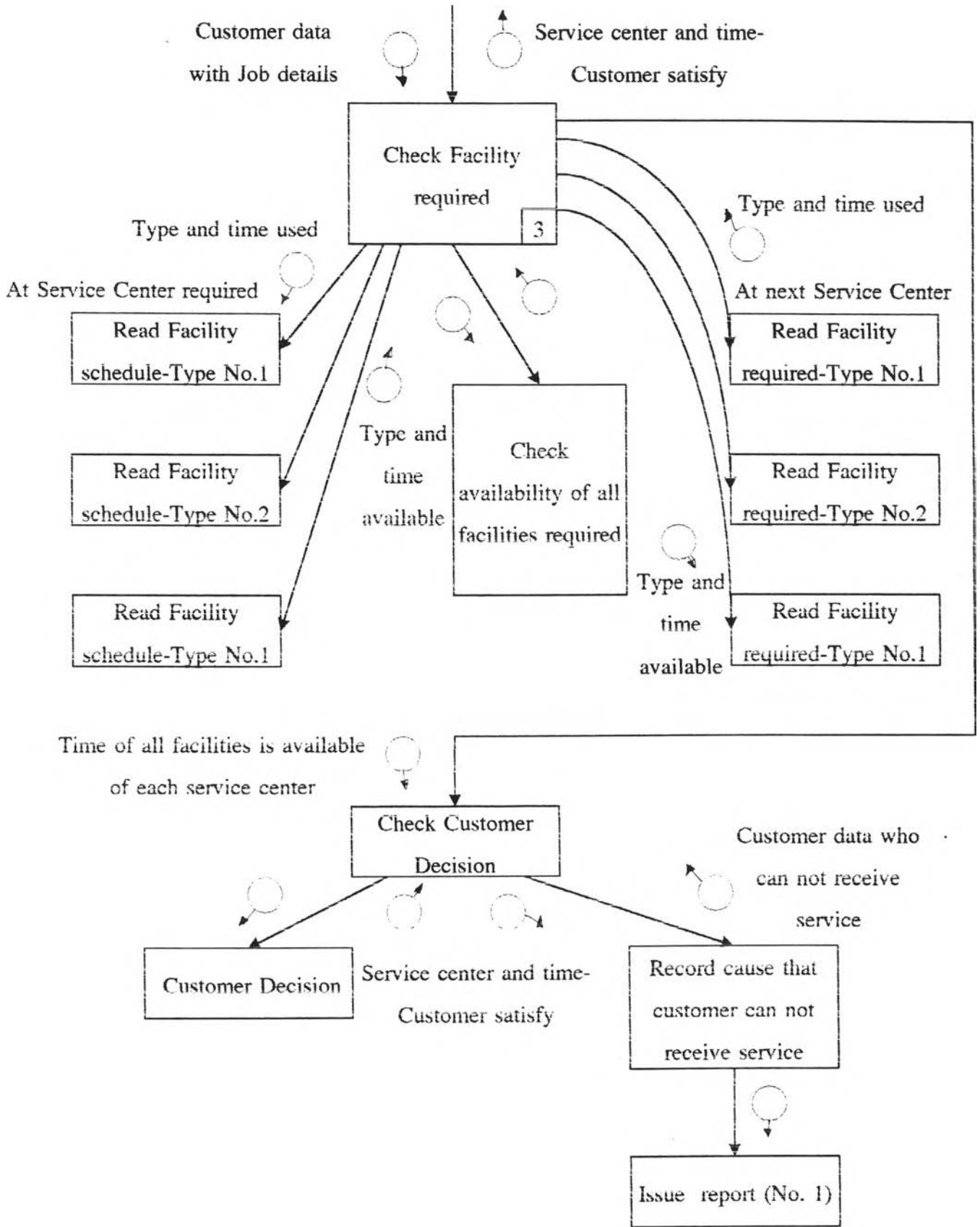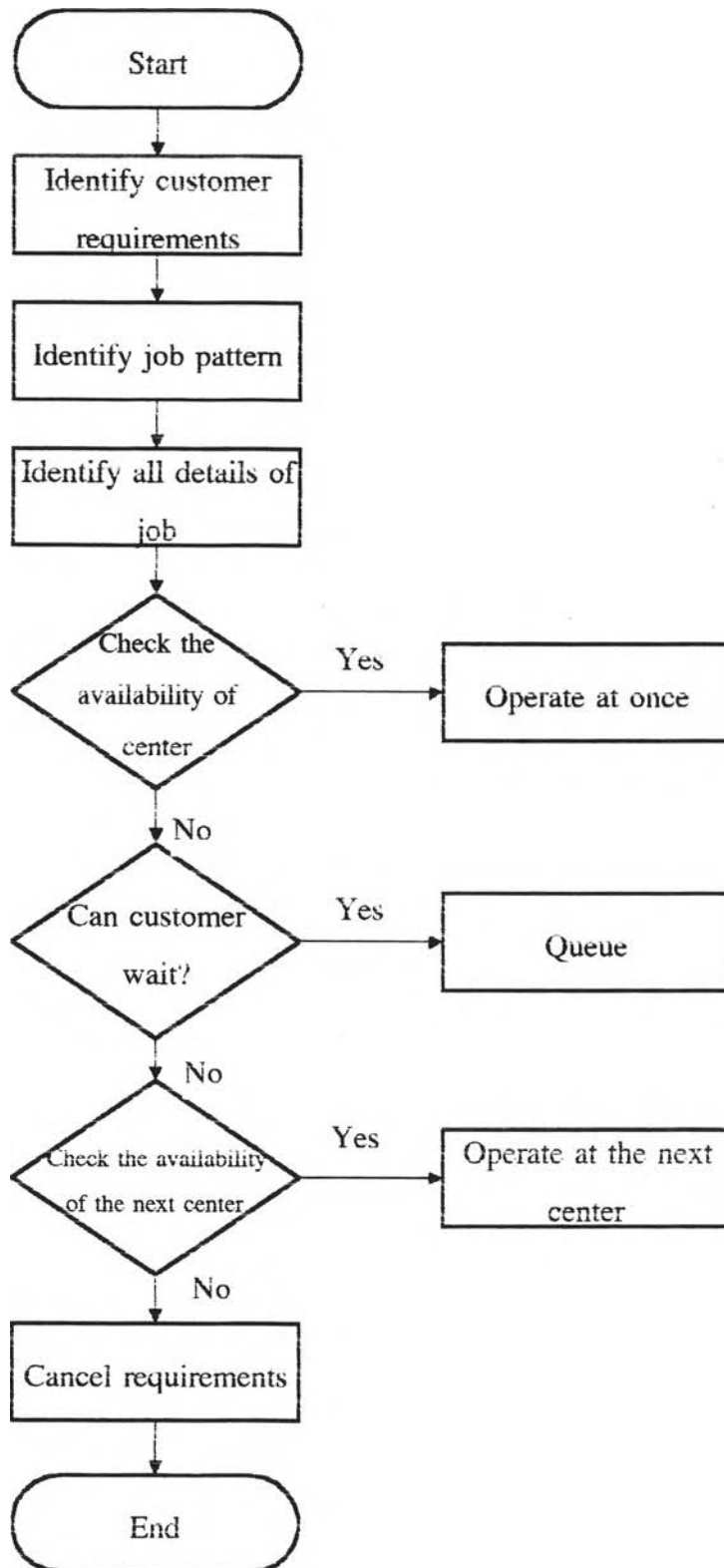
Figure 4-4 : Check Facility (No. 3)

Figure 4-5 : Job Allocation Procedure

4. Open job

This module is to record job and facilities status before start operating job. Current date is brought to compare with expected start date. The comparison result together with previous status of facilities will define the status of job and facilities required.

First, when expected start time has not yet due, status of job and facilities are still marked to **Reserved.** No action is required to this job.

Second, when expected start date is due or overdue but the customer is not ready to get service, **Wait** status is marked to the job and **Reserved** status is still marked to the job.

Third, when expected start date is due or overdue and the customer is ready to get service. But, at that time, reserved facilities are still used by previous job. **Queue** status is marked to the job and status of facilities is still the same as previous status.

Last, when job is started at expected start date. **Operating** status is marked to job and required facilities. Data of this case are sent to the next module to continue processing

For the first and fourth case, schedules of job and facilities are runned as planned. This is a normal case. Data of these jobs are collected as regular basis.

For the second and third case, schedule of job and facilities can not acted as planned. This is an irregular case. Data of these jobs have to be reported for monitoring.
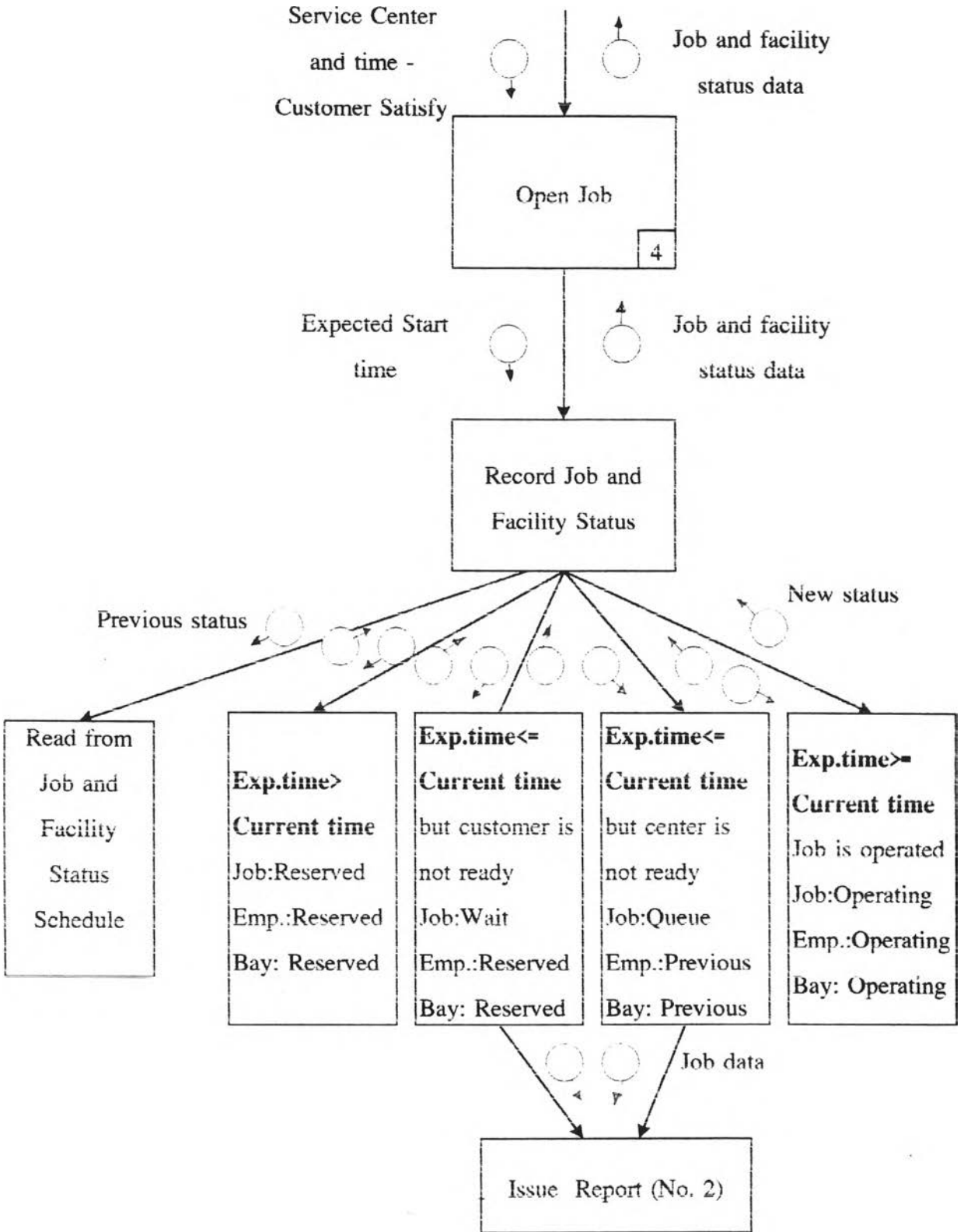
Service Center
and time -
Customer Satisfy

Job and facility
status data

Open Job

4

Expected Start
time

Job and facility
status data

**Record Job and
Facility Status**

Previous status

New status

| Read from Job and Facility Status Schedule | **Exp.time> Current time** Job:Reserved Emp.:Reserved Bay: Reserved | **Exp.time<= Current time** but customer is not ready Job:Wait Emp.:Reserved Bay: Reserved | **Exp.time<= Current time** but center is not ready Job:Queue Emp.:Previous Bay: Previous | **Exp.time>= Current time** Job is operated Job:Operating Emp.:Operating Bay: Operating |

Job data

Issue Report (No. 2)

Figure 4-6 : Open Job (No. 4)

5. Operate job

This module is to investigate job and facility during operating phase. This phase. most job have to use spare part to replace the old one. So. the step concerning spare part will also be described.

During job operation. foreman has to monitor job progress by updating job status, facilities status, percentage of job progress. He will update these parameters in three times. First. update the parameters every evening as daily activity. Second. update the parameters as soon as job has got any problems or can not continue operation. Last. update when job is completed.

If job is operated smoothly. foreman will record **Operating** to job and facilities status and actual job progress. On the other hand. if job has got any problems. foreman will record **Pending** to job and facillities status. For bay status. when job operated in the bay has got **Pending** status. this job has to be removed from the bay. So. bay status will have no **Pending** status. It will change from. for example. **Operating** to **Free.**

Together with **Pending** status. **Remark** of pending has to be specified. No facilities such as **No Bay. No Welder. No Mechanic. No Electrician. No Spare Part. No Service Car** means that these facilities are not available when they are required by the job. **Outsourcing** means that some components of the product are send to repaired by sub-contractor. **No Response** means that some jobs have no response from customer to continue operating.

Most jobs use spare part in its opaeration. If spare parts are available in the store. they are issued to the job. Job operation can run smoothly. On the other hand. if required spare parts are not in the store. job can not continue operating. This case **Pending** status is marked to job and facilities with remark of **No Spare Part.**

Classified by status. Job and facilities can be reported in two aspects. The first is operating status. This aspect is normal case. It is not necessary to pay special attention. The secomd is pending status. This aspect is exception case. Job of this case should be monitored and its data should be collected and reported to managemnet for any corrective actions
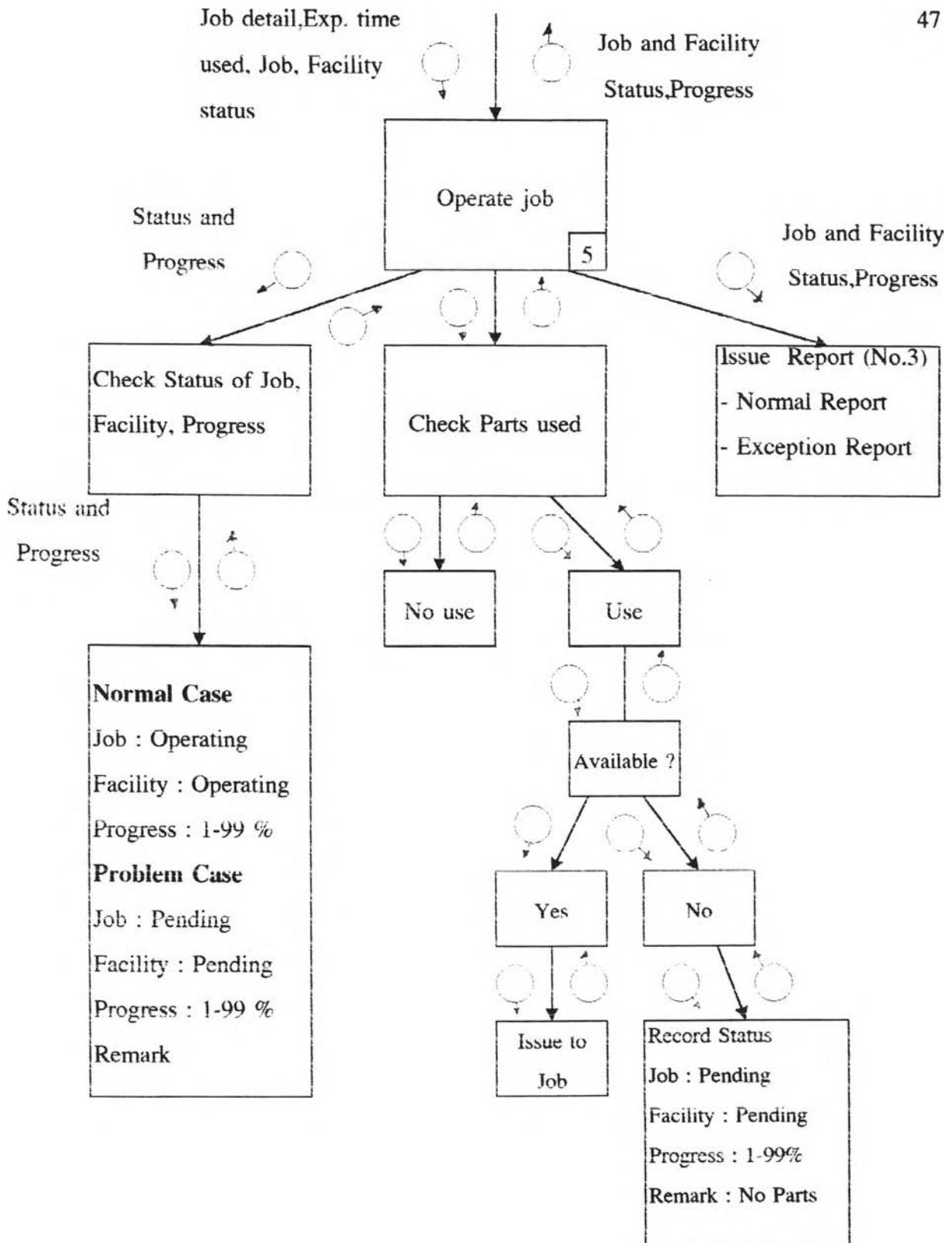
Job detail,Exp. time
used. Job, Facility
status

Job and Facility
Status,Progress

Operate job

5

Status and
Progress

Job and Facility
Status,Progress

Check Status of Job,
Facility, Progress

Check Parts used

Issue Report (No.3)
- Normal Report
- Exception Report

Status and
Progress

No use

Use

Available ?

Normal Case
Job : Operating
Facility : Operating
Progress : 1-99 %
Problem Case
Job : Pending
Facility : Pending
Progress : 1-99 %
Remark

Yes

No

Issue to
Job

Record Status
Job : Pending
Facility : Pending
Progress : 1-99%
Remark : No Parts

Figure 4-7 : Operate Job (No. 5)

6. Resume job

This module is to resume job with **Pending** status to be **Operating** status. Usually, foreman updates job and facility status. He will investigate the pending job and remark. At the same time, he will check with report and find out whether cause of pending is correct. If the cause is not corrected, job status, facility status, job progress is still the same. If the cause is corrected, he will define facility required and check with schedule of concerned facility (same as Module No.3). The resumed job are ordered as the newest job according to First-Come, First-Served basis and can not be removed to other service centers. Status of resumed job will be changed from **Pending** to **Operating** again. This job type takes time to operate longer than expected, when it was opened. Likewise, customer will has to wait longer. So, it should be recorded as problem case.
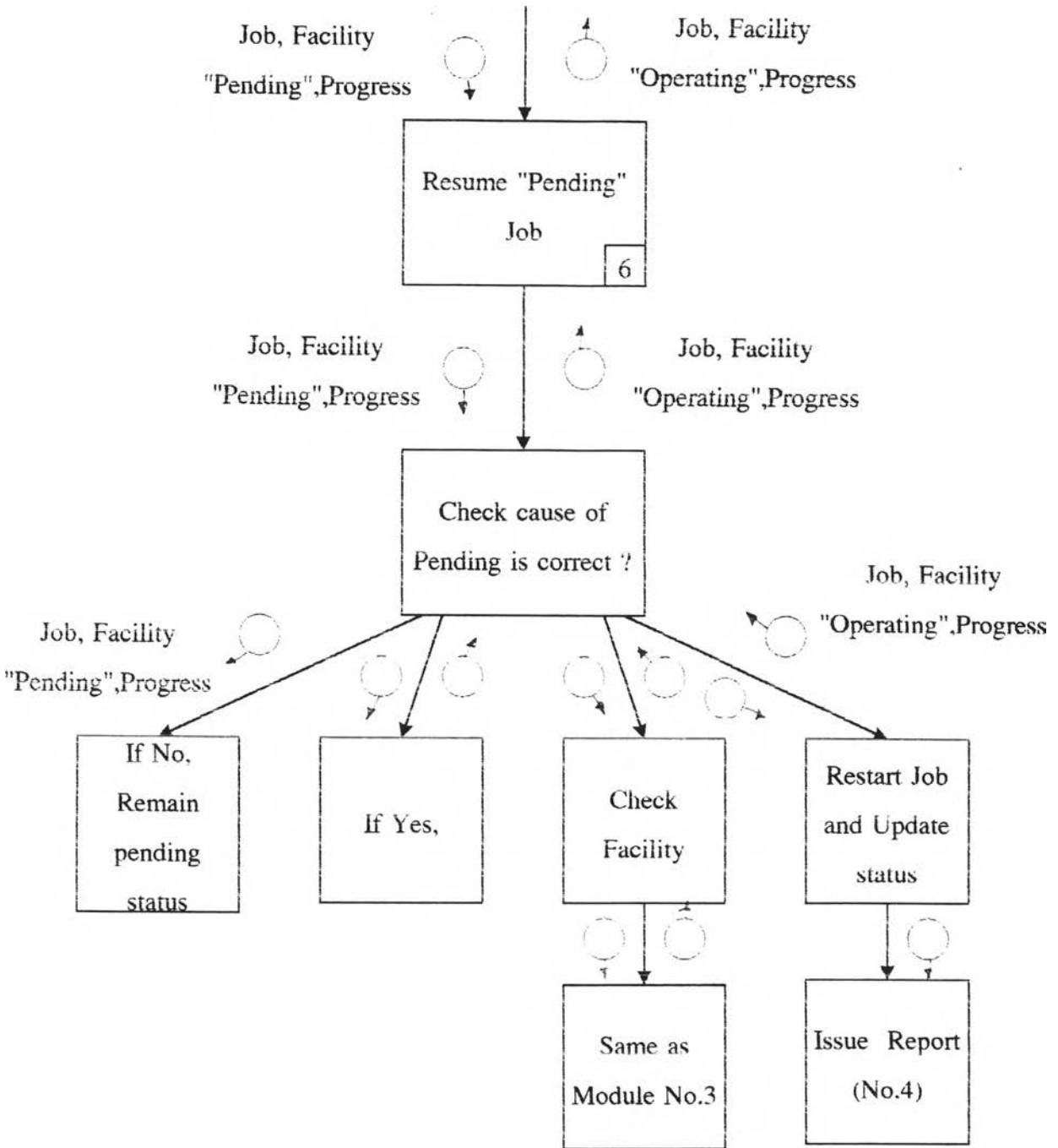
Figure 4-8 : Resume Job (No. 6)

7. Close job

This module is to close job of 100% progress. If job is operated with progress less than 100%, it has to be continue operating and marked status as actual. If job is completed with 100% progress, it is ready to close. Data of job with 100% are marked by foreman and sent to administrative officer to process document work. For cost calculation, two costs are automatically calculated by the program. First is labour cost. It is calculated by multiply Number of operating hours with wage per hour of each employee working for this job. Sum of individual labour cost is total labor cost. Second is part cost. This cost calculated from total price of spare part consumed by this job. After that, summary report are prepared and submitted to service manager to sign for approval. Finally, finished job report is issued.
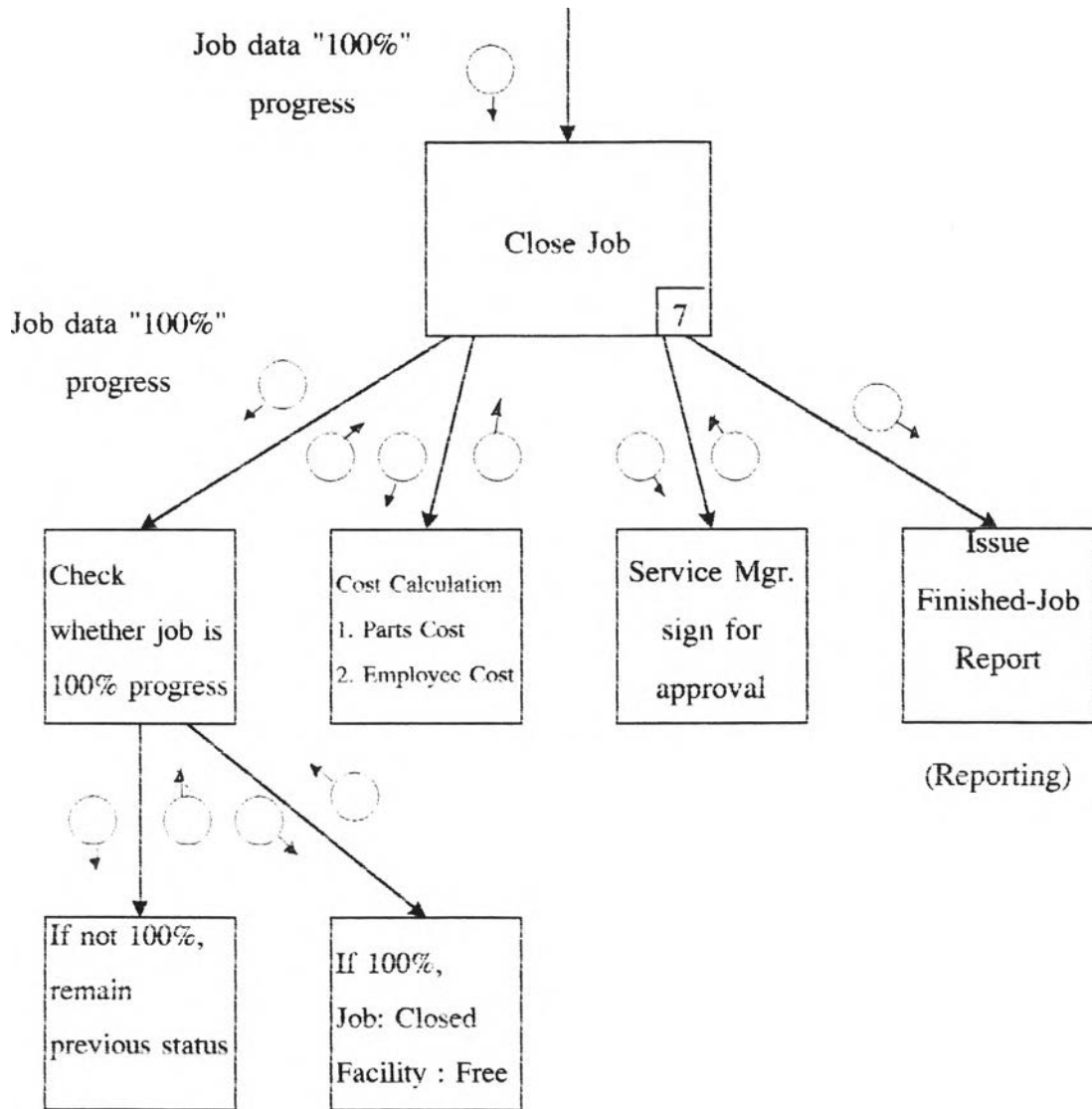
Job data "100%"

progress

Job data "100%"

progress

Close Job

7

Check

whether job is

100% progress

Cost Calculation

1. Parts Cost

2. Employee Cost

Service Mgr.

sign for

approval

Issue

Finished-Job

Report

(Reporting)

If not 100%,

remain

previous status

If 100%,

Job: Closed

Facility : Free

Figure 4-9 : Close Job (No. 7)

4.1.2 Monitoring and Reporting System

In order to serve the company core policy of customer satisfaction and optimize facility utilization , four main monitoring stage have been established and can be investigated from reporting system which, additionally, serving other management reporting aspects.

The four monitoring stages are as follows:

First stage Monitoring : In process of registering job orders and verifying resources availability. the purpose is to concern the canceled job orders that cannot be served due to resource limitation.

Second stage Monitoring : In process of starting job orders on the appointed date. the purpose is to concern job status that will be flagged in **Reserved, Operating, Wait** and **Queue**.

Third stage Monitoring : During operating process. the purpose is to concern the ongoing job status that will be marked in two statuses of **Operating** and **Pending** .

Forth stage Monitoring : The purpose is mainly for well-treating all pending jobs that may have some obstacles resulting unloaded from process and waiting for taking actions.

For reporting system, all reports are designed in two main aspects of normal and exception reports that can be matched to all monitoring aspects also for other management purposes.

First stage Monitoring :   Job Order cancellation in process of verifying resources.

In the process of registering customer requirements and verifying capacity and parts, there are three statuses of **Reserved, Cancel, Can't service** be happened.

Reserved   is for a normal job order.

Cancel   is marked when having problems of resource limitation.

Can't service   is marked for showing an inability to operate due to other brand name's products or etc.

In process of registering customer requirements and assigning resources, Four decisions will be taken :

1. Normal Case. Having enough resources on a selected service center, all resources are reserved to that Job order-- **Reserved** is marked on the job order and on bay and manpower schedule.

2. In case of cannot replace service center or the customer accept to wait, the same service center and capacity are marked **Reserved** but acquired longer expected time.

3. If not, with the time constraint, the decision of selecting another available service center to that job order will be taken-- **Reserved** is marked in the same way.

4. In case of resource shortage and customer disagree to wait, the jobs are canceled. The **Cancel** will be marked. Furthermore, this **Cancel** status can be used when facing unsolved problems during on-going process.

Among these three status, **Cancel** is the most concern. It is the first step to measure customer serving level by calculated the fulfillment ratio by total number

of cancel job orders divided to total received job orders at that period comparing to goal. By the way, the ratio will be calculated for all exception status.

Reporting :

        Reserved   shows in **Job normal report** by selecting **Reserved.**

        Cancel   shows in **Job exception report** by selecting **Cancel.**

        Can't service   shows in **Job exception report** by selecting **Can't service.**

Moreover, in exception report will show the percentage of each status category job orders to total job orders that is a meaningful ratio measuring level of job order fulfillment.

For order cancellation, the company may sets a target of job order fulfillment at, for example, 80 percents which means that the canceled orders should not be greater than 20 percent.

Second stage Monitoring : Reserved, Operating, Wait and Queue status in process of starting job orders.

When a job order is opened and reserved for bay and manpower used, the customer is acknowledged the appointed date which serviced products must be delivered or be prepared them on site. Four statuses will happen during this process and the actions should be taken.

        Reserved

        Meaning   The appointed date of that job order has not yet due.

        Actions   No action.

        Operating

        Meaning   The products are on service center or on site on appointed time and can start operation.

Actions	All reserved resources are allocated to this job order and already in process. Job progression is evaluated in percentage on daily basis.

Wait

Meaning	On the appointed date, the products are not delivered to service center in time or cannot operate at site due to customer cancellation. Therefore, the reserved resources are not assigned to this order and may be assigned to another proper order which depends on the foreman decision.
Actions	This job order is marked **Wait**. The administrative officer should contact customer within 30 minutes after appointed time. Another job can be assigned to that reserved capacity, if proper. Later, foreman will decide whether this job order should be rescheduled on the basis of First Come- First Served that will remarked to **Reserved** or to **Cancel**. Hence, marked **Wait** will be happened in case of not taking any action to that customer cancellation.
	However, this case should not be frequently occurred. It can be prevented, if the administrative officers confirmed to customer at least a day before appointed date.

Queue

Meaning	The order must be waiting for vacant resource due to longer actual time used of previous job.
Actions	This order will be flagged in **Queue** until this order can be started and change status to **Operating**. The longer expected finish date will be acknowledged to that customer and also other customers that may effect. The other

and also other customers that may effect. The other following orders may be rescheduled both bay and manpower.

Reporting :

Reserved   shows in **Job normal report** selecting **Reserved**.

Operating   shows in **Job normal report** selecting **Operating**.

Wait   shows in **Job exception report** selecting **Wait**.

Queue   shows in **Job exception report** selecting **Queue**.

For **Wait** and **Queue** status. the exception report will show the remarks explaining brief causes and also the fulfillment ratio.

Third stage Monitoring :   Pending job order during operating process.

During actual operation. the job orders will have two statuses of **Operating** and **Pending** status. **Operating** is for a normal order status. **Pending** means a job order is interrupted due to some obstacles occurred. The obstacles are as follows:

1. Parts are shortage which waiting for parts purchasing or next transferring.

2. Bay and/or manpower are busy which waiting for reschedule bay and/or manpower.

3. The actual time and resources needed are much more than expectation. The pending job will stop operation and will be taken out from bay if a time period need for taking actions. This job will be marked **Pending** until the additional costs and longer expected period are admitted by customers and authorized by service center's manager.

3. Cannot contact customer during operating process.

4. Other obstacles.

Reporting :

Operating	shows in **Job normal report** selecting **Operating.**
	The job progression is evaluated daily in percentage.
Pending	shows in **Job exception Report** selecting **Pending**.
	The remarks will show job progression and cause of pending.

Forth stage Monitoring : Tracking all pending jobs.

This last stage mainly considers the Pending jobs to be well-treated. All pending jobs can be listed from **Job exception report** which shows remark of pending problem also the actual time used (days) that is a signal shown how long each job is pending and still not taking any action.

The **Pending** job that can solve its obstacle will be resumed the **Reserved** status into process by rescheduling bay and manpower used and issuing the parts for that job order. The later finished date and additional costs will be reminded to customer. Please be noted that the pending period is still counted into the actual time used for showing total time used for that job order.

The **Closed** status will be marked to finished job orders. Costs will be updated in **Job summary** and the finished job will be prepared to delivery to customer.

Reporting :

Operating	shows in **Job normal report** selecting **Operating**.
Pending	shows in **Job exception report** selecting **Pending**.
Closed	shows in **Job normal report** selecting **Closed,**
	and be shown in **Job summary** for costing detail.

The Pending Job report should be printed weekly and be authorized by service center's manager to assure that all necessary actions have been taking.

Reporting System :

After the job orders are opened and capacity are reserved. all movements of each job order will be updated in **Job Control screen** daily including job status. remarks. progression. The part used for each job order will be updated in **Part-used Screen** daily. Finally. the **Job Summary** will be wrapped up all costs (parts and labor cost are automatically calculated) input in this job orders.

All reports are as follows.

1. Job normal report

Selection term :

1. Period	On line. Daily. Weekly. Twice a month. Monthly.
2. Status	**Reserved. Operating. Closed.**
3. Center	selected service center.
Monitoring purpose :	To review normal case in each status.
Management purpose :	Can review total job orders in a time period for all or each status and also for each service center.

2. Job exception report

Selection term :

1. Period	On line. Daily. Weekly. Twice a month. Monthly.
2. Status	**Can't service, Cancel, Wait, Queue, Pending**
3. Center	selected service center.
Monitoring purpose :	- To reduce canceled job orders.

- To assure that Pending job orders are well-
solved.

- To review Wait and Queue status.

Management purpose :   - To increase customer satisfaction.

- To reduce Wait and queue status.

3. Job order pattern report

Selection term   :

1. Period   :   On line. Daily. Weekly. Twice a month. Monthly.

2. Pattern   :   Installation. Preventive Maintenance.

Break-down Maintenance.

3. Center   :   selected service center.

Monitoring purpose   :   --

Management purpose :   To manage all resources by reviewing all job

orders categorized by job pattern per service

center overall in a time period.

4. Employee Report

Selection term   :

1. Period   Current time.

2. Status   Reserved. Operating. Pending. Free.

3. Center   :   selected service center.

Monitoring purpose   :   To view each employee schedule.

Management purpose :   To manage manpower capacity.

5. Bay Report

Selection term   :

1. Period	Current time.
2. Status	Reserved. Operating. Free.
3. Center :	selected service center.
Monitoring purpose :	To view bay schedule in detail by job orders.
Management purpose :	To manage bay capacity in detail.

6. Capacity Report

Selection term   :

1. Period	On line. Daily. Weekly. Twice a month. Monthly.
2. Status	Reserved. Free. Pending. Operating.
3. Center	selected service center.
4. Type	Bay or Employee
Monitoring purpose :	To view vacant capacity.
Management purpose :	To manage all capacity schedules categorized into reserved. operating and vacant capacity in each service center or in total capacity aspect.

7. Part Used Report

Selection term   :

1. Job No.	Job No. that user wants to investigate.
Monitoring purpose :	To view details of part input to each job order.
Management purpose :	--

8. Job summary

Selection term   :

1. Job No.	Job No. that user wants to investigate
Monitoring purpose :	To view details and cost of each job order
Management purpose :	--

4.2 Inventory Control Model

From data mentioned on chapter three. we can categorize existing inventory activities into three groups as follows:

Issue inventory from store

This activity occurs when there is a requirement from job or customer of each service center. This can be shown as figure below:

Head office ─────────────────► Service center 1.2.3.....

Service center ─────────────────► Spare part sales. Job operation

Figure 4-10 : Issue inventory activity

Transfer inventory between service center

This activity occurs when inventory of any item of each center is lower than the level it should be. This level is estimated by store staff of each service center. So. inventory is transferred from head office or the service center which owns greater inventory to the service center which need inventory of that item. The flow of inventory can be illustrated as figure below:
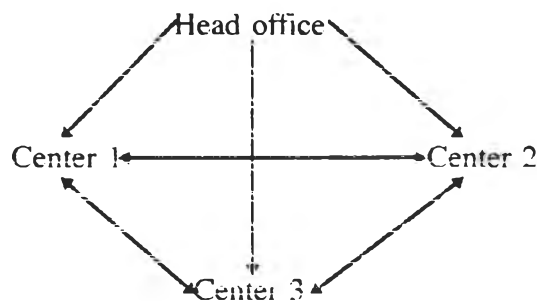
Figure 4-11 Transfer inventory activity

Re-order form supplier

This activity occurs when inventory level of any item at head office is lower than the level it should be. So. staff at head office will order new quantity to replenish from supplier.

Supplier ─────────────────► Head office

Figure 4-12 : Re-order inventory activity

Model Development

Proposed solution

Appropriate plan for spare parts stock in each service center and head office main stock.

Proposed concept and assumption

1. Transfer from head office to service center on weekly basis

The company has currently to do many transactions in transfer activity. It happens any time that each service center want to get spare parts. This causes the too much flow of documents. Store officers have to work all times. They can not do other necessary activities. Also. it is difficult to define time to check the level of inventory.

The proposed transfer method is to only let head office transfer spare parts to each service center every week and not allow all service centers transfer spare parts among one another. Lead time to deliver inventory from head office to service centers is not later than one day. So. it is not necessary to consider lead time for this activity. The method is to apply **Fair Share** technique to this activity.

2. Reorder by consider order quantity and reorder point.

For order point. it should consider costs of ordering and carrying cost. Economic order quantity can serve this purpose because it results in minimum total ordering and carrying costs. As actual usage rate has never constant. it is considered to be variable usage. This is the same as lead time. it varied from 5 to 84 days: data from the year of 1996. Both two parameters affect safety stock and service level. So. it is suitable to apply Reorder point with variable usage rates and lead time model to determine reorder point at head office main stock.

Procedure

Transfer activity

1. Classify all spare part items into ABC group

All spare parts can be classified into A. B. C groups by considering the product of its price multiplied by usage rate. Price is the property of each item. But usage rate. we can use data of last year-1996. Then, rank the results by descending. Group A accounts for about 80% of total value. Group B accounts for around 15% of total value. Group C accounts for the rest value.

Part No. [1]	Part Name [2]	Price [3]	1996 usage rate [4]	Annual baht [5] = [3] * [4]
H1456	xxxx	xx	xxxx	xxxxx
H2345	xxxx	xxx	xxxx	xxxxx
H1458	xxxx	xxx	xxx	xxxx
B4567	xxxx	xxxx	xx	xxx
C7894	xxxx	xx	xxxx	xxxxx
:	:	:	:	:
:	:	:	:	:
X4568	xxxx	xxxx	xxxx	xxxx
			Total value	xxxxx

Figure 4-13 : Classify all part items into A. B. C group

For example. if the summation of annual baht of H1456 and H2345 is around 80% of total value. these two part item are classified into A group. If the summation of annual baht of H1458. B4567. C7894 and the next part No. is about 15% of total value. they are classified into B group. The rest part items are classified into C group.

2. Calculate usage rate of any part no. of each service center

Usage rate of next week is forecasted by using moving average technique. It can be calculated by the following equation:

$$M_t = (x_i+x_{i-1}+x_{i-2}+x_{i-3}+\ldots\ldots\ldots+ x_{i-N+1}) / N$$

where M_i = forecast value of week t

x_t = Actual value at the end of week t

N = Number of weeks observed

First we start from t is current week and N=2. Calculate backward to 12 weeks (3 months) for spare parts of group A and 24 weeks (6 months) for spare parts for group B. Spare parts for group C may be negligible for this step because its usage rate is very few. So, we will have 11 and 23 pair values of actual and forecast usage rate for group A and B orderly. Then apply the following standard deviation to calculate forecast errors

$$o = \sqrt{\sum e_i^2 / N}$$

where   e = difference between forecast and actual value

N = number of forecast

Standard deviation indicates the accuracy of forecasting. The less standard deviation, the more accuracy forecast value.

Increase N from 2 to 3,4,5.......... to 12 for group A and to 24 for group B. Select M_i which is originated from minimum standard deviation. This M_i is the best forecast value for the next week according to the following equation:

$$\hat{x}_i(T) = \hat{a}_t, \qquad T = t+1, t+2, \ldots\ldots$$

where $\hat{x}_i(T)$ = forecast of x_T made at the end of period t

$\hat{a}_i$ = estimate of a made at the end of period t.

With the procedure in this step, we will get the best weekly usage rate o every service center

3. Calculate total usage rate from usage rate of each service center

Usage rate of each center is brought to calculate total usage rate of total system. It is summarized by the following equation:

$$\sum r = r_{tA} + r_{tB} + r_{tc} + \ldots\ldots\ldots\ldots + r_{tx}$$

where $\sum r$ = total usage rate

x = service center A, B, C

r_{tx} = usage rate of center x at week t

4. Compare total usage rate with on hand quantity of head office

The comparison can be described by the following equation:

$$T = Q - \sum r$$

where T = Difference between Q and r

Q = On hand quantity at head office

If T is non negative value, it means that the on hand quantity at head office are greater than or equal to total usage rate. So, the parts can be immediately transferred to each service center in the quantity equaled to usage rate of each service center. On the other hand, if T is negative value, it means that the limited quantity at head office must be allocated to each service center in suitable way. **Fair Share** can serve this required procedure.

5. Calculate Fair Share quantity

5.1 Calculate the total supply available in the system

Total system supply = $Q + \sum Q_x$

where Q_x = on hand quantity at service center x

5.2 Calculate the number of weeks supply available in the system

Number of weeks supply = Total system supply/$\sum r$

5.3 Calculate tentative transfer quantity to each service center

$$q_i = (\text{Number of weeks supply})r_i - Q_x$$

where q_i = Tentative transfer quantity to each service center

5.4 If all the quantities calculated in step 5.3 are non negative, these are final transfer quantities. If not, remove the centers with negative tentative transfer quantities from consideration and return to step 5.1

From this model, transfer activity can be operated weekly in the quantity required by each service center or **Fair Share** quantity. The former is occurred when on hand at head office is enough to distributed to each service center. The latter is occurred when on hand quantity at head office is less than the total usage rate of each service center.

Re-order activity

This activity is proposed to use **Economic Order Quantity (EOQ) and Reorder Point (ROP)** model to determine the plan to re-order inventory. This plan can determine how much to reorder and when to reorder spare parts at head office main stock.

EOQ is used to calculated the optimal order quantity. It can be determined by the following equation.

$$Q_0 = \overline{(2DS)/H}$$

where Q_0 = Optimal order quantity

D = Usage rate, in units per year

S = Ordering cost, in baht

H = Carrying cost, in percentage of purchase price

This equation makes sum of the costs of ordering and carrying the turnover stock will be minimized.

From the data collected by accounting department of this company, the two types of costs can be described as follows:

Ordering cost

This type of cost can not be exactly defined into fix quantity. It is calculated from the concerned costs as below:

1. Freight - charged about 10-20% of inventory cost

2. Import duty - charged about 0-40% of inventory cost

3. Insurance - charged about 0.18-0.20% of inventory cost

4. Clearing - charged about 3-14% of inventory cost

The record from accounting department shows that average value of imported spare parts per order is 180.000 baht and total ordering cost per order is around 30% of imported value or 54.000 baht.

Carrying cost

This type of cost is calculated from the concerned expense as follows:

1. Interest rate- charged about 15% per year

2. Monthly expense

2.1 Salary expense

2.1.1 Four store staffs. salary of 5.500 baht each = 4x5.500 = 22.000 baht

2.1.2 Two store officers. salary of 6.500 baht each = 2x6.500 = 13.000 baht

2.2 Rental expense for store = 15.000 baht

So, total expense per month = 22.000 + 13.000 + 15.000 = 50.000 baht or 50.000x12 = 600.000 baht per year

Total inventory value at the end of 1996 was 8.556.924 baht. So, the percentage of carrying cost resulted from yearly expense is about 600.000/8.556.924*100 = 7% So, total carrying cost equals interest rate plus yearly expense is equal the following equation:

Total carrying cost = Interest rate + Salary expense + Rental expense

$$= 15\% + 7\%$$

$$= 21\% \text{ per year}$$

Usage rate per year

In addition to ordering and carrying cost, another variable is usage rate per year. It should be calculated from past data. For this model, it should bring the record of the previous year, 1996, to be the base data and plus or minus how many percent of change as required.

Therefore, the order quantity equation can be re-written on the following form:

$$Q_o = \sqrt{(2*D*54.000 \text{ baht}) / (30\%)}$$

$$= 600\sqrt{D}$$

where D = Forecast demand of current year

Order quantity

Under normal circumstances of this company, two factors are variable. These are usage rate and lead time. The first varies as normal. The second is more clearly exhibited by the data from logistics department. It revealed that forty six spare parts orders were placed to supplier in 1996. The spare parts were delivered to the company by air freight with lead time of five to eighty four days. Its average was 23.20 days and standard deviation was 12.97 days.

So, the model suitable to this pattern must be based on variable demand and lead time. It is assumed that both of them are normally distributed. The reorder point equation for this case is

$$ROP = \text{Expected usage during lead time} + \text{Safety stock}$$

$$= \bar{d}(\overline{LT}) + z\sqrt{\overline{LT}\sigma_d^2 + \bar{d}^2\sigma_{LT}^2}$$

where $\bar{d}$ = Average usage rate

σ_d = Standard deviation of usage rate

$\overline{LT}$ = Average lead time

σ_{LT} = Standard deviation of lead time

z = Number of standard deviations from the mean

Variables in the above equation can be described as follows:

1. Average usage rate (d) and its standard deviation (o_d)

This value can be calculated by collecting all usage rate of each service centers to be the total usage rate per week and then applied moving average technique and standard deviations to determine the best forecast value of average usage rate.

2. Average lead time (LT) and its standard deviations (o_{LT})

This value is as same as of the year of 1996.

3. Number of standard deviations from the service level (z)

This value is depended on desired service level. For this company, it should be defined service level to each inventory group as follows:

Inventory group	Service level	z- value
A	0.99	2.33
B	0.95	1.65
C	0.80	0.84

Table 4-1 : z-value based on service level

So, the ROP equation can be re-written in the following form:

$$ROP = 23.20(\bar{d}) + z\sqrt{(23.20)o_d^2 + \bar{d}^2(12.97)^2}$$
$$= 23.20(\bar{d}) + z\sqrt{(23.20)o_d^2 + 168.22*\bar{d}^2}$$