CHAPTER VI

EVALUATION

6.1 Introduction

In this chapter, the evaluation processes are presented to compare the existing system and the proposed system. First, the new warehouse layout is determined for improvement. There are two improved operations; Picking operation and Shelf-Filling operation. Then the improvement in transportation operation is determined. There are three schedules to compare: 1. Existing Schedule, 2. Proposed Schedule and 3. Optimal Schedule.

6.2 Improvement in the Warehouse

For a warehouse, the proposed layout can be evaluated in two operations. First, the picking operation and second the shelf-filling operation. Then the reduction of distance analysis is calculated. In evaluating the proposed layout, the data of items picking and shelf-filling was collected in November.

6.2.1 Picking Operations

There are two groups of ordered items; machining department and assembly department in which the picking tour is different. For machining department's ordered items, these items are heavy in weight and large in size. In addition, the amount of ordered items is a lot. Therefore, a single picking tour is done for each item. The frequency of order for the machining department is collected in November and the distance that each item travels was carried out in Chapter 4. The result is the proposed distance subtracted by the existing distance. It is then multiplied by the ordering

frequency of each item. Table 6.1 exhibits the reduced distance of the proposed layout in the machining department's ordered items.

Table 6.1 : Comparison of distance in November from the machining department.

Model	Type	Part No.	Part name	Existing Distance (m.)	Proposed Distance (m.)	Frequency of order (times)	Reduced distance (m.)
2L-II	W/P	237	BODY	62.08	5.08	8	-456
4D56	W/P	382	BODY	62.08	15.24	10	-468.4
4G1	W/P	558	BODY	50.68	2.54	0	0
4G1E	O/P	431	CASE	82.4	15.24	0	0
4G9E	O/P	451	CASE	62.08	20.94	4	-164.56
4JA1	W/P	55	CENTER	65.92	12.7	0	0
4JA1	O/P	33	SHAFT(SHORT)	50.68	10.16	9	-364.68
4JA1	O/P	35	SHAFT(LONG)	50.68	10.16	17	-688.84
4JA1	O/P	25	COVER	67.16	12.7	9	-490.14
4JA1	O/P	32	GEAR(RAW)	50.68	12.7	8	-303.84
4M4	O/P	386	GEAR	65.92	2.54	5	-316.9
AIR	COMP	368	GEAR HEAD	60.84	2.54	5	-291.5
AIR	COMP	369	CYLINDER	55.76	5.08	8	-405.44
AIR	COMP	367	CRANK SHAFT	50.68	2.54	17	-818.38
BD25	W/P	125	BODY	55.76	5.08	7	-354.76
BD25	O/P	100	BODY	67.16	7.62	4	-238.16
BD25	W/P	127	BODY	60.84	7.62	0	0
BD25	O/P	105	GEAR DRIVE	55.76	15.24	3	-121.56
BD25	W/P	128	COVER	60.84	2.54	0	0
HF	F/C	213	FRONT COVER	82.4	5.08	10	-773.2
HF	O/P	215	COVER	67.16	5.08	5	-310.4
P-CAR	W/P	283	BODY	77.32	7.62	12	-836.4
P-CAR	O/P	256	COVER GEAR	67.16	7.62	15	-893.1
P-CAR	O/P	255	CASE FRONT	72.24	10.16	24	-1489.92
P-CAR	O/P	271	BOLT	59.6	7.62	0	0

P-CAR	W/P	284	HUB	76.08	10.16	0	0
TD27	W/P	132	WHEEL	65.92	8.24	0	0
TD27	W/P	130	BODY	71	13.32	2	-115.36
TD27	W/P	131	COVER	76.08	8.24	5	-339.2
4G9E	O/P	453	CASE	44.36	12.7	3	-94.98
						Total	-10335.72

For the assembly department's ordered items, these items are grouped into models. They are ordered to be assembled into each model. Therefore, they are always ordered according to a model and not as a single item. The ordering frequency for each model is collected in November and the comparison of distance is done in Chapter 4 so that the total reduction of distance is calculated. Table 6.2 shows the comparison of the existing distance and the proposed distance in November for the assembly department.

Table 6.2 : Comparison of distance in November for the assembly department.

No.	Model and Type	Existing Distance (m.)	Proposed Distance (m.)	Frequency of order (times)	Reduced distance (m.)
1	4G1E O/P	59.6	30.42	2	-58.36
2	4G1E W/P	36.8	27.88	1	-8.92
3	4G1 W/P	39.28	18.4	22	-459.36
4	4G9 W/P	49.44	27.88	5	-107.8
5	4M4 O/P	53.28	65.92	12	151.68
6	P-CAR O/P	64.68	38.04	26	-692.64
7	P-CAR W/P	59.6	21.56	23	-874.92
8	4JA1 C/F	32.96	21.56	25	-285
9	4JA1 D/C	38.04	53.28	1	15.24
10	4JA1 R/V	38.04	41.88	14	53.76
11	4JA1 O/P	48.2	48.2	17	0
12	4JA1 W/P	53.28	41.88	17	-193.8
13	Y71 O/P	31.72	48.2	2	32.96
14	Y71 W/P	26.64	48.2	1	21.56

15	2L-II W/P	21.56	39.28	12	212.64
16	5L W/P	21.56	53.28	10	317.2
17	VQ O/P	53.28	59.6	1	6.32
18	VQ W/P	64.68	54.52	2	-20.32
19	BD25 RS	59.6	38.04	10	-215.6
20	TD27 RS	21.56	49.44	10	278.8
21	BD25 O/P	32.96	43.12	6	60.96
22	BD25 W/P	32.96	32.96	18	0
23	TD27 W/P	58.36	49.44	10	-89.2
24	HF O/P	48.2	39.28	12	-107.04
25	HF W/P	48.2	39.28	7	-62.44
26	4G9E O/P	49.44	91.32	10	418.8
				Total	-1605.48

In the picking operations, the picking tour distance in the proposed layout is 11941.2 metres (10335.72 m. + 1605.48 m.) lower than the existing layout.

6.2.2 Shelf-filling Operations

After the supplied items have been checked by the Quality Control department, they are delivered to their locations. Forklifts are used in the materials handling process. For each supplier, assuming that all the supplied items are delivered to their location within one tour. As a result, the shelf-filling tour distance is determined for each supplier in Chapter 4 and then the frequency of delivering of each supplier is collected in November. The comparison of shelf-filling tour distance between existing warehouse layout and proposed warehouse layout is shown in Table 6.3.

Table 6.3 : Comparison of distance in November in shelf-filling operation.

No.	Supplier Name	Existing Distance (m.)	New Distance (m.)	Frequency of supply (times)	Reduced distance (m.)
1	ADS	82.4	10.16	2	-144.48
2	AP	74.84	91.32	2	32.96

3	ASA	82.4	41.26	2	-82.28
4	BEW	43.12	38.04	1	-5.08
5	BTA	69.76	43.12	2	-53.28
6	CMM	27.88	16.48	1	-11.4
7	DM	64.68	71	0	0
8	ICC	60.84	10.16	0	0
9	IFC	76.08	20.32	1	-55.76
10	ITO	71	63.44	3	-22.68
11	JBT	43.12	59.6	2	32.96
12	KOYO	64.68	91.32	1	26.64
13	KTH	85	96.4	3	34.2
14	MSC	54.52	27.88	1	-26.64
15	NHK	69.76	79.92	1	10.16
16	NSO	58.36	81.16	0	0
17	P&SON	60.84	10.16	0	0
18	PCR	27.88	16.48	1	-11.4
19	PR2	43.12	36.8	0	0
20	SGT	59.6	74.84	2	30.48
21	SMEC	91.32	58.36	1	-32.96
22	SMTE	71	25.4	0	0
23	SNF	65.92	25.4	2	-81.04
24	SSI	54.52	38.04	1	-16.48
25	SW	48.2	43.12	0	0
26	TAC	59.6	43.12	1	-16.48
27	TAP	101.48	95.16	0	0
28	TEP	102.72	58.36	1	-44.36
29	TSS	69.76	96.4	1	26.64
				Total	-410.28

The reduction of shelf-filling tour distance is not much compare with the picking tour because the proposed warehouse layout is based on grouping items in term of models. In addition, one supplier may supply many items in many models therefore the shelf-filling tour is rather spreading. As a result, the distance in shelf-filling for both the

existing layout and the proposed layout warehouses is not different. An arrangement in a warehouse only matter with the picking distance and not the shelf-filling distance.

6.2.3 Distance Reduction Analysis

The cost in a warehouse is associated with many factors such as labour cost, factory overhead cost, and materials handling cost. When the new warehouse layout was determined in November, the details of the distance reduction were determined as follows.

The existing distance and the proposed distance are multiplied by the frequency of each item/model. The total existing distance and the total proposed distance for each activity are shown in Table 6.4 below.

Table 6.4 : Total existing distance and total proposed distance.

Activity	Total Existing Distance (m.)	Total Proposed Distance (m.)	Reduced Distance (m.)
Order picking of machining department	**11,945.28**	**1,609.56**	**10,335.72**
Order picking of assembly department	**12,422.44**	**10,816.96**	**1,605.48**
Shelf-filling	**2,165.92**	**1,755.64**	**410.28**

The total distance is the sum of;

- Order picking of machining department 11,945.28 metres
- Order picking of assembly department 12,422.44 metres
- Shelf-filling 2,165.92 metres

Total 26,533.64 metres

The total reduction of distance is

- Order picking of machining department reduces 10,335.72 metres
- Order picking of assembly department reduced 1,605.48 metres
- Shelf-filling reduced 410.28 metres

Total 12,351.48 metres

Therefore, the materials handling routing can reduce the total distance in percentage as

$$\frac{\text{Total distance reduction x 100}}{\text{Total distance}}$$

Therefore, $\frac{12351.48}{26533.64} x100 = 46.55\%$

6.2.4 Time Saving Analysis

Assuming that the speed of transport of the workers and the forklifts are constant. Therefore, the time reduction can be calculated as follows.

The speed of transport of the workers is approximately 0.75 metres per second and the approximate speed of the forklifts is 1 metre per second.

Order picking of machining department , The forklifts are used to carry these items.

The distance reduction		=	10335.72 metres
As	speed	=	distance / time
Therefore, the time reduction		=	10335.72 / 1
		=	10335.72 seconds

In picking items ordered by the assembly department, the workers use pushcarts to carry the items. As a result, the speed of the materials handling is 0.75 metres per second.

The distance reduction		=	1605.48 metres
As	speed	=	distance / time
Therefore, the time reduction		=	1605.48 / 0.75
		=	2140.64 seconds

In shelf-filling, the forklifts are used to carry the items. As a result, the speed of the materials handling is 1 metre per second.

The distance reduction	=	410.28 metres

As speed	=	distance / time
Therefore, the time reduction	=	410.28 / 1
	=	410.28 seconds
∴ The Total time reduction	=	10335.72 + 2140.64 + 410.28
	=	12886.64 seconds
or, the total time saving	=	3.58 hours

This evaluation has been carried out within a period of one month. Therefore, in one year, this proposed warehouse layout can save up to 42.96 working hours approximately.

6.2.5 Advantages

- The materials handling routing helps decreasing the operation cost because the picking tour distance and shelf-filling tour distance are reduced.
- The workers have more time to do other activities such as stock checking, maintenance of materials handling equipment, and preparing the loading of finished products into a truck.
- The materials handling equipment has lower maintenance cost because they are not used as much as in the existing warehouse layout. In addition, batteries are charged continuously therefore, the lifetime of the batteries is longer.
- The proposed warehouse layout provides systematic techniques in allocating an item into the warehouse and the worker can pick it up easily. In addition, these techniques may be applied to other departments or other companies.
- The waiting time in the machining and assembly departments could be reduced.
- The systematic warehouse layout supports the information to the company's database and to the automatic warehouse systems in the future.

6.2.6 Disadvantages

- The company has to move most of items in the warehouse into the new locations. This process requires additional cost, time consumption, and may affect the production line.
- The workers in the warehouse may not accept the change.
- An additional task to reallocate items has to be carried out when the new warehouse layout is applied.
- If the frequency of use in each model is changed, this new warehouse layout will be out of date. The company has to adjust some locations. This problem arises from both the existing system and the proposed system because the fixed location strategy has been used in both cases.

6.3 Improvement in Transportation

The company has four trucks to deliver finished products to customers. There are eleven major customers. In this thesis, some customers are grouped according to their locations which are near to one another and hence a delivery truck can visit them in one tour. The details of the customers in this company is shown in Table 6.5.

Table 6.5 : Details of the customers and their schedule.

Customer No.	Existing route	Delivery schedule	Group
1	Suvintavong, Chalongkung, Ladkrabang Industrial Estate	Everyday	-
2	Suvintavong, Minburi-Romkral	Once a week	-
3	Bangna-Trad km.21	Everyday	-
4	Kabinburi-Koraj	3 times/week	-

5	Bangpakong Industrial Estate	Everyday	-
6	Bangpakong Industrial Estate	Everyday	-
7	New Pattaya Bypass, Laem Chabung Industrial Estate	Everyday	Area B
8	New Pattaya Bypass, Lam Chabung Industrial Estate	Everyday	Area B
9	New Pattaya Bypass, Lam Chabung Industrial Estate	2 times/week	Area B
10	Banbung, Huakunjar, Sattaheap Industrial Estate	Everyday	Area C
11	Banbung, Huakunjar, Sattaheap Industrial Estate	Everyday	Area C

The Customer nos. 7, 8 and 9 are grouped and called area B while the customer nos. 10 and 11 are grouped and called area C so that the scheduling process can be done easily.

The comparison is determined to exhibit the proper schedule. Then the cost for each schedule is calculated to evaluate the proposed schedule.

6.3.1 Schedule and Routing

In Chapter 5, the existing schedule and the proposed schedule have been presented. In this section, their routes and schedules are compared. In addition, the optimal schedule is proposed by eliminating some constraints that may affect the truck selection for example, the demand for Isuzu truck and the capacity of each truck. The customers map should be considered prior to the comparison. Figure 6.1 shows the location of the eleven major customers.

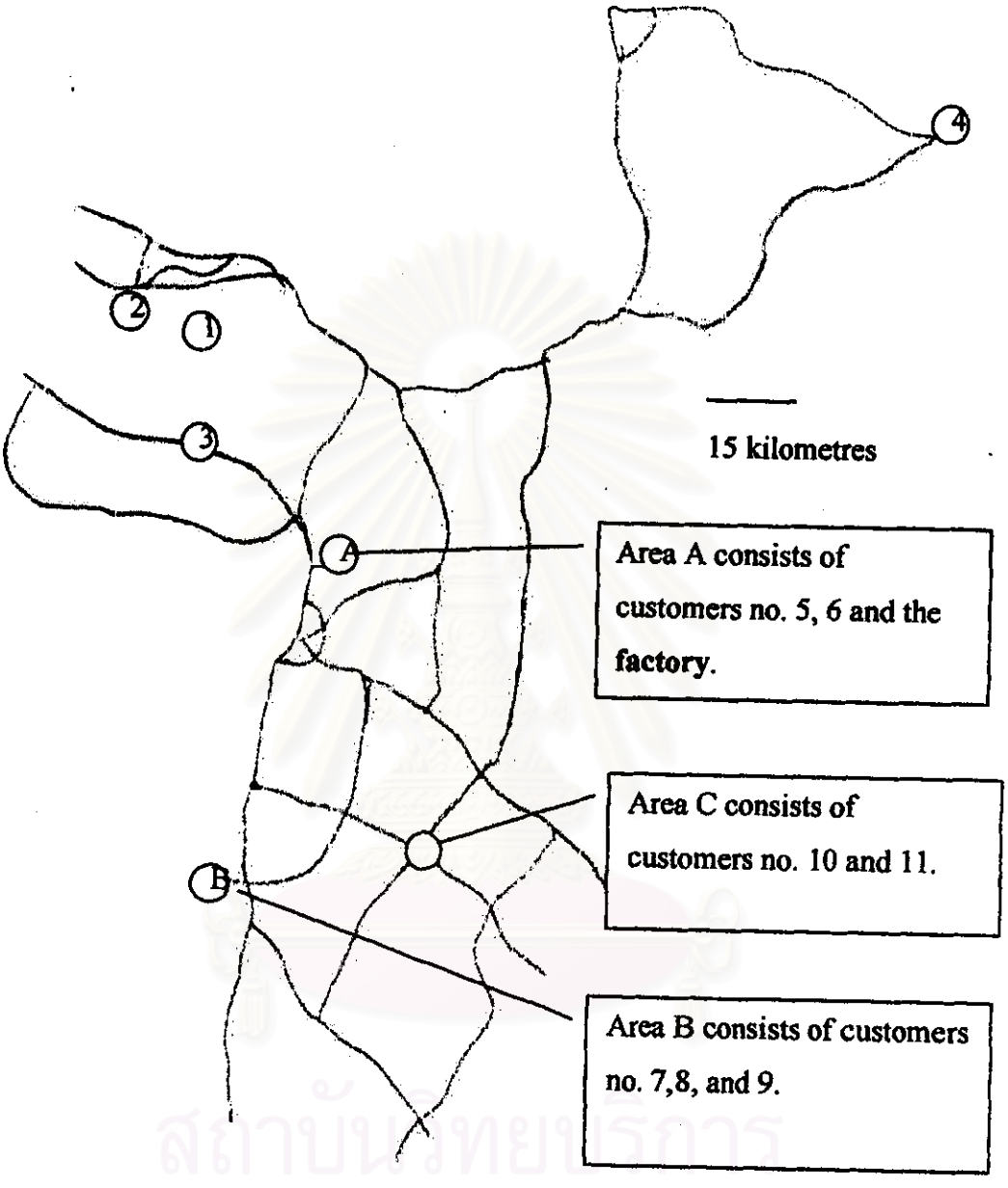

Fig. 6.1 : Location of the eleven major customers.

There are three schedules to be compared; the existing schedule, the proposed schedule, and the optimal schedule. The proposed schedule can be applied to this company immediately. However, the optimal schedule has eliminated some constraint such as the capacity of the truck. Therefore, the company may increase the capacity of

the truck so that the optimal schedule can be applied. The details of the schedule are as follows.

Existing Schedule

The six wheels Isuzu truck is used to deliver finished products to customer nos. 1 and 3 in the morning everyday. Then it will be used to deliver to customer no. 6 in the afternoon everyday. The route of this six wheels Isuzu truck has been determined in Chapter 5. There are two delivery tours. Firstly, the driver goes to customer no. 1 and then to customer no. 3 and back to the company. Secondly, the driver goes to customer no. 6 and then back to the company.

The six wheels Mitsubishi truck is used to delivery finished products to customer nos. 7, 8 and 9 in the morning only and then to deliver for another company in the afternoon.

For the two small trucks, they are used to deliver to five customers. Customer nos. 5, 10 and 11 require the finished products everyday. However, customer nos. 2 and 4 require the finished products once a week and 3 times per week respectively. Therefore, the schedule depends on the requirement of the customer nos. 2 and 4. There are four possibilities in this situation. Table 6.6 shows the possibilities for the customer nos. 2 and 4.

Table 6.6 : Four possibilities of the customer nos. 2 and 4.

Case	Customer no. 2	Customer no. 4
1	Yes	No
2	No	Yes
3	Yes	Yes
4	No	No

Case 1: the small ISUZU truck delivers finished products to the customer nos. 2 and 5. The small TOYOTA truck serves customers nos. 10 and 11.

Case 2: the small ISUZU truck serves customers nos. 10, 11 and 5 while the small TOYOTA truck serves the customer no. 4.

Case 3: the small ISUZU truck delivers finished products to the customer no. 2 and then deliver to the customer no. 5. The small TOYOTA truck

serves the customer no. 4. For customer nos. 10 and 11, the company has to use a subcontracted truck.

Case 4: the small ISUZU truck delivers finished products to the customer no. 5 and customers nos. 10 and 11.

Proposed Schedule

The schedule is not much different from the existing schedule. For the six wheels Isuzu truck, it is used to deliver finished products to customer nos. 1, 3 and 6. However, the route is not the same as the existing route. This truck should use the Motorway on the way to customer nos. 1 and 3 as shown in Fig. 6.2 below.

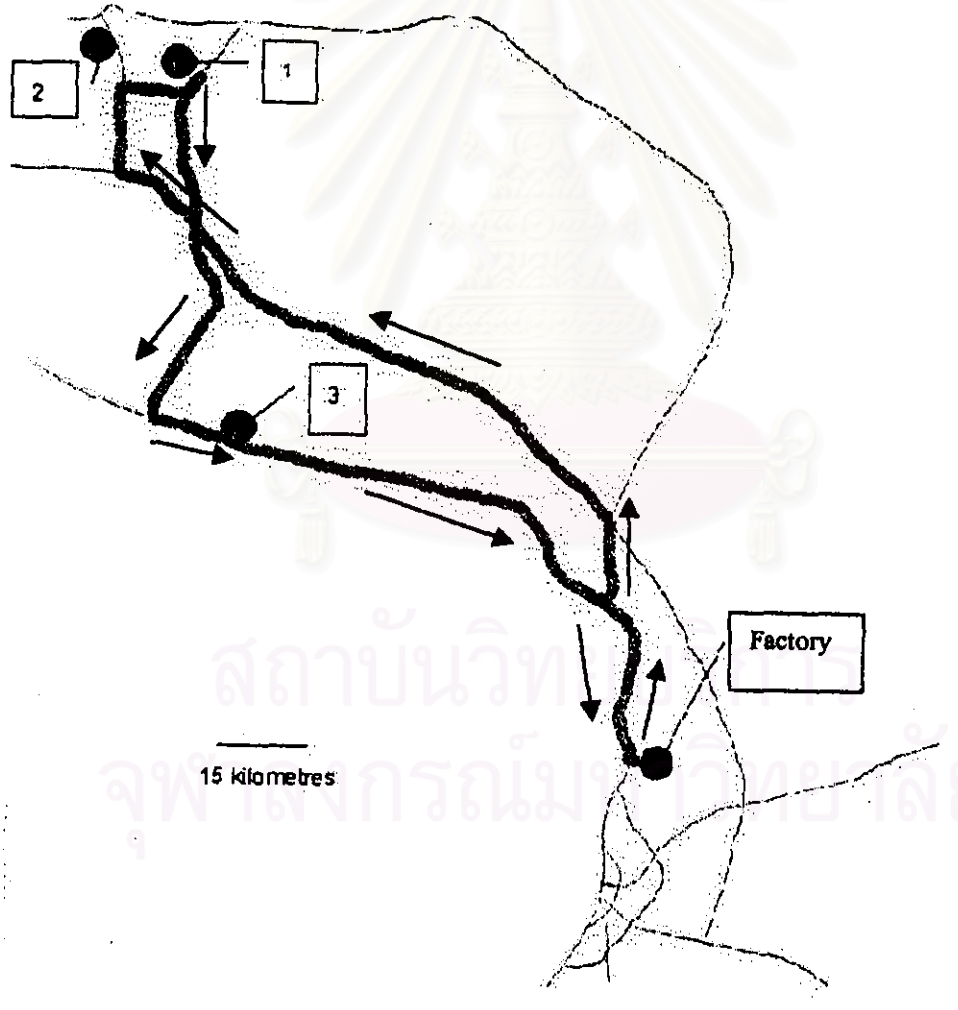

Fig. 6.2 : The route from the company to customer nos. 1 and 3.

For this route, the company can save 22 kilometres. In addition, the driver can have lunch at the company. Therefore, the cost of the driver's lunch of 30 baht can be

saved. In the afternoon, this truck is used to deliver finished products to the customer no. 6. The route is the same as the existing route.

The six wheels Mitsubishi truck is used to deliver the finished products to customer nos. 7, 8 and 9 in the morning only and then to deliver for another company in the afternoon. The route is the same as the existing route as shown in Fig. 6.3.

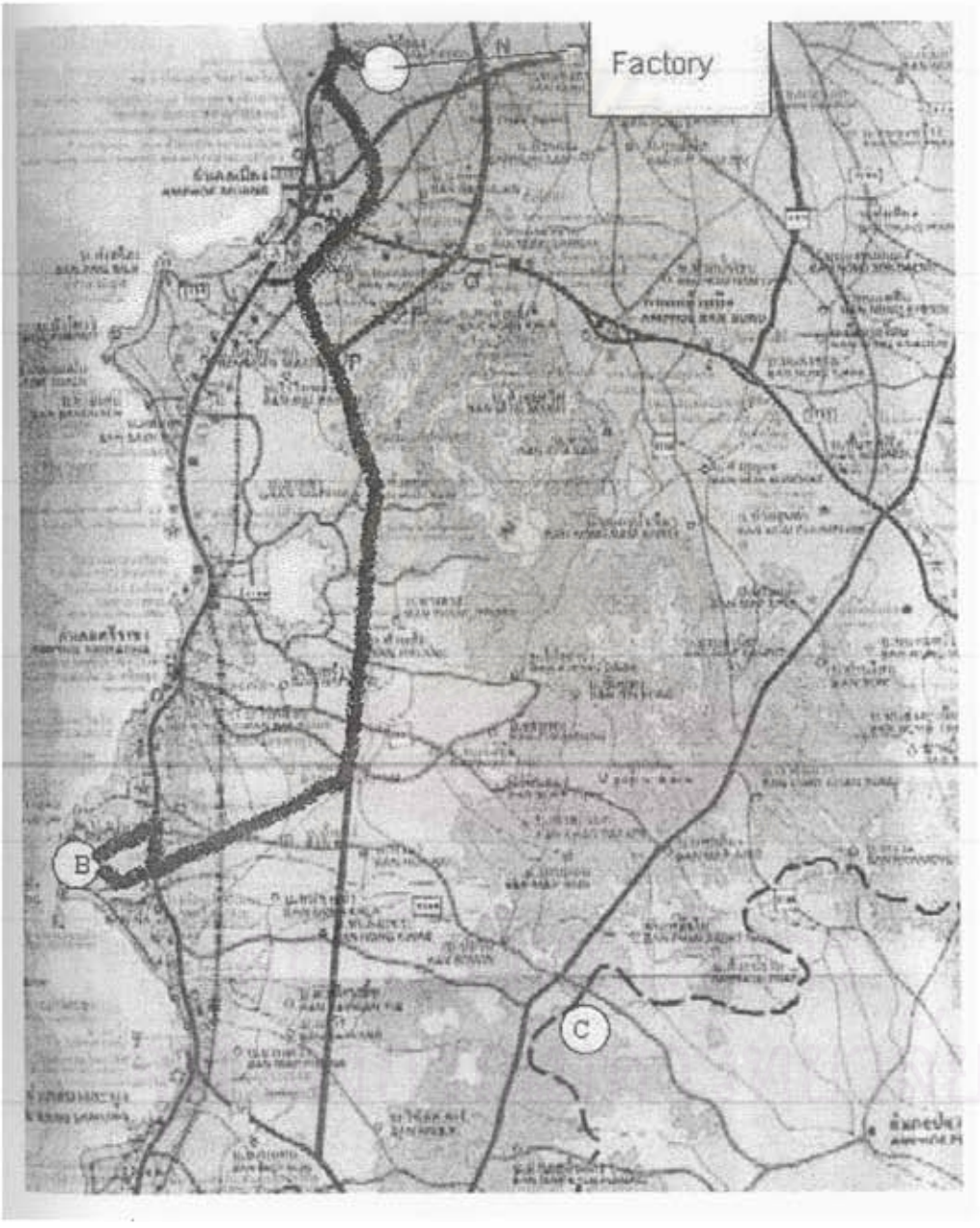

Fig. 6.3 : The route to customer nos. 7, 8 and 9 (Area B).

For the two small trucks, they are also used to deliver to the customer nos. 2, 4, 5, 10 and 11. The routes to customer nos. 4 and 5 is the same as the existing route but the routes to customer nos. 2, 10 and 11 are slightly different.

For the customer no. 2, the small truck should travel via the Motorway as shown in Fig. 6.4.

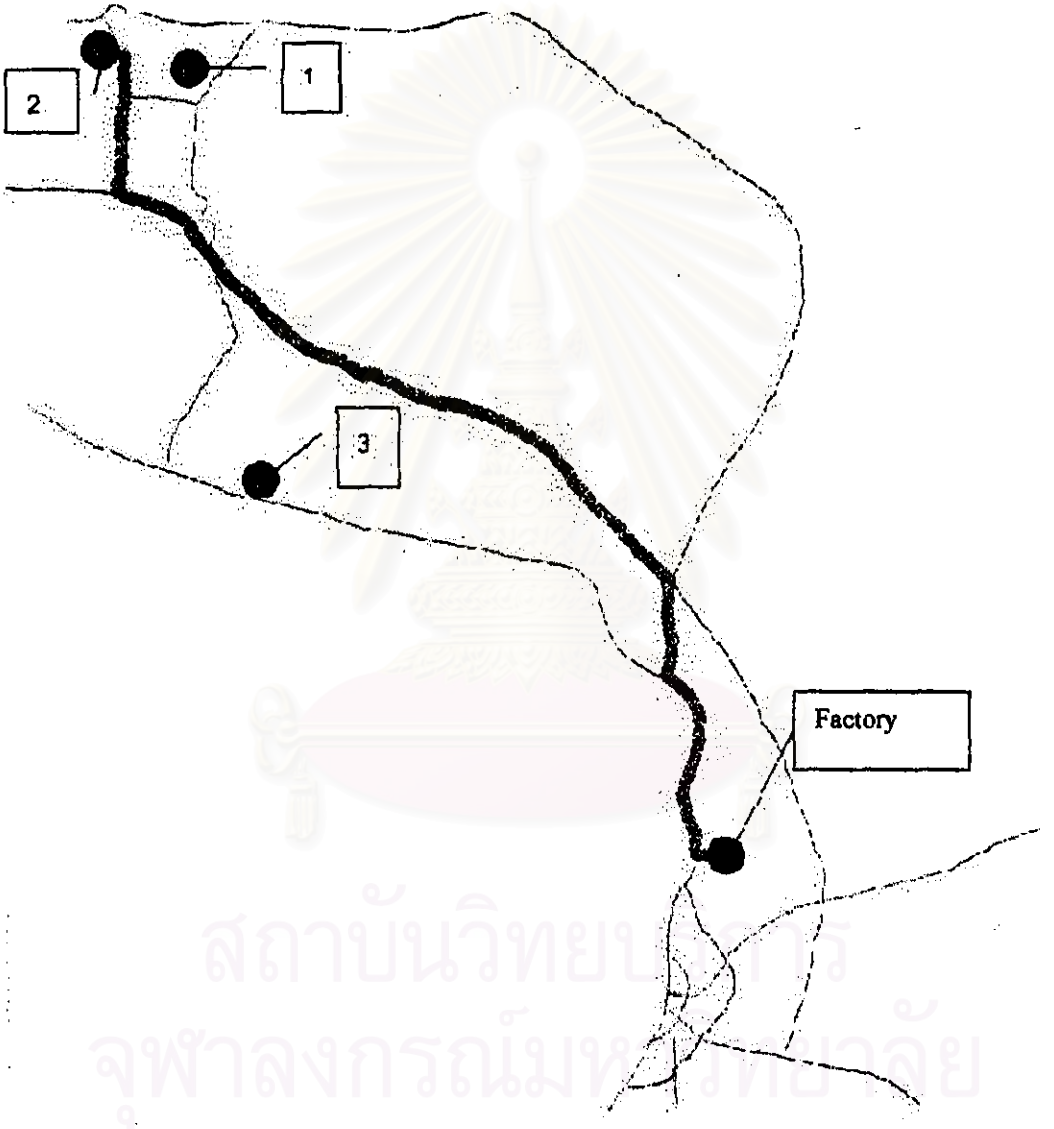

Fig. 6.4 : The proposed route to customer no. 2 via the Motorway.

When the drivers travel by this route, the distance of about 63 kilometres can be reduced. However, this route costs 60 baht for the Motorway fee.

For the customer nos. 10 and 11, the new route is shown in Fig 6.5.

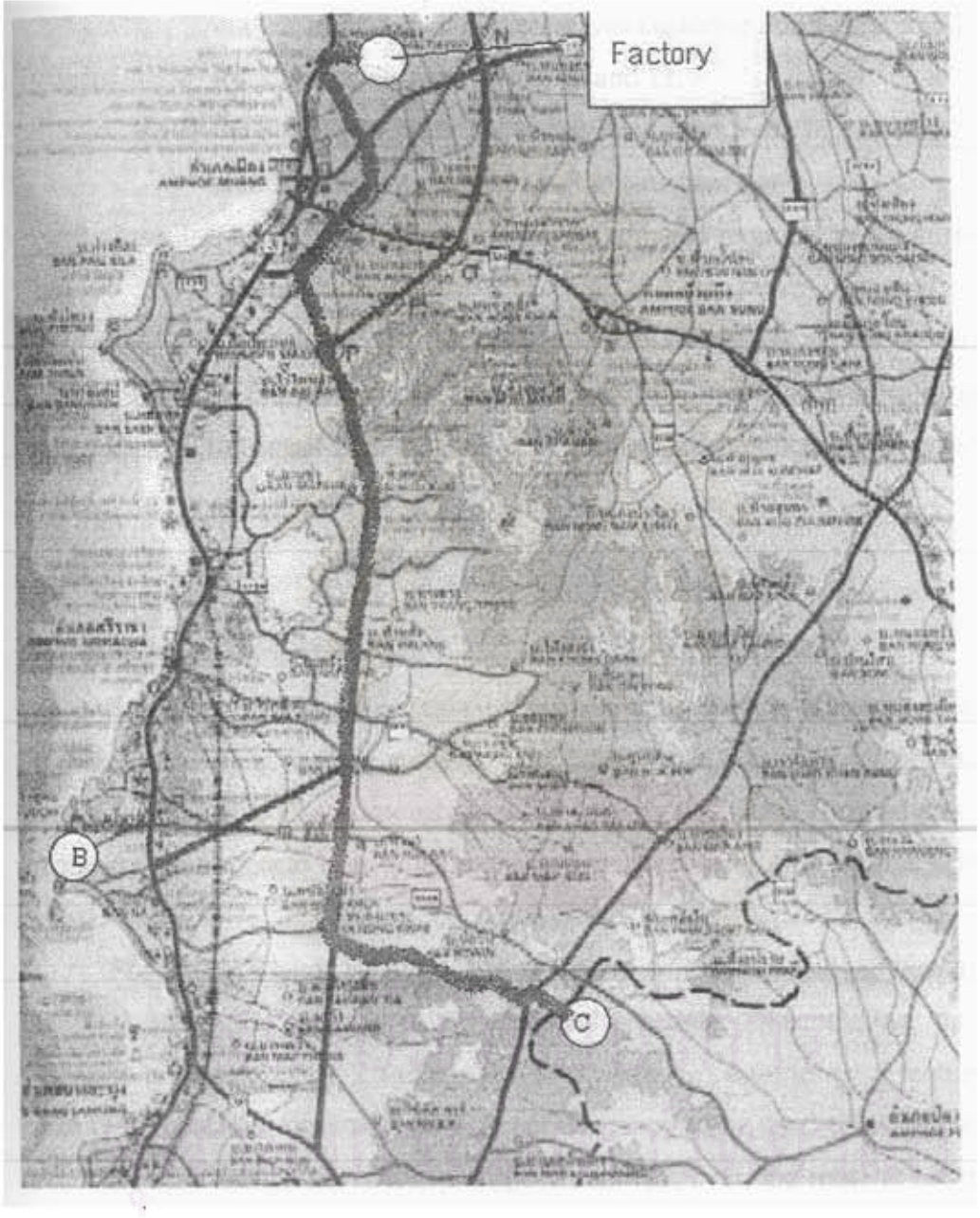

Fig. 6.5 : The proposed route to the customer nos. 10 and 11.

After the new routes are determined, the schedules are prepared by considering the same way as the existing schedule. Customer nos. 5, 10 and 11 require the finished products everyday but customer nos. 2 and 4 require the finished products once a week

and 3 times per week respectively. As a result, the schedule is dependent upon the requirement of the customer nos. 2 and 4. There are four possibilities in this situation as in the existing schedule shown in Table 6.6. Each case is shown as follows.

Case 1: the small ISUZU truck delivers finished products to the customer nos. 2 via the Motorway and then serves customer no. 5. The small TOYOTA truck serves customers nos. 10 and 11.

Case 2: the small ISUZU truck serves customers nos. 10, 11 and 5 while the small TOYOTA truck serves the customer no. 4.

Case 3: the small ISUZU truck delivers finished products to the customer no. 2 via the Motorway in the morning and then serves customers nos. 10 and 11 in the afternoon. The small TOYOTA truck serves the customer no. 4. For the customer no. 5, the company has to use a subcontracted truck.

Case 4: the small ISUZU truck delivers finished products to the customer no. 5 and customers nos. 10 and 11.

Optimal schedule

Some constraints are not taken into account so that the optimal schedule can be presented. Assuming that the customer nos. 1 and 2 can accept all the brands of trucks. The six wheels trucks have enough capacity to carry additional finished products to the customers which locate near to the existing tour. As a result, the optimal schedule is as follows.

For the six wheels Isuzu truck, it is used to deliver finished products to customer nos. 1, 3 and 6 the same as in the proposed schedule. Nevertheless, the truck can deliver to customer nos. 1, 2 and 3 in one tour when the customer no. 2 requires finished products. Therefore, the small truck is not necessary to be used to deliver to customer no. 2. This can reduce the cost of transportation. However, the route is not the same as in the proposed route. This truck should use the Motorway on the way to customer nos. 2, 1 and 3 as shown in Fig. 6.6.

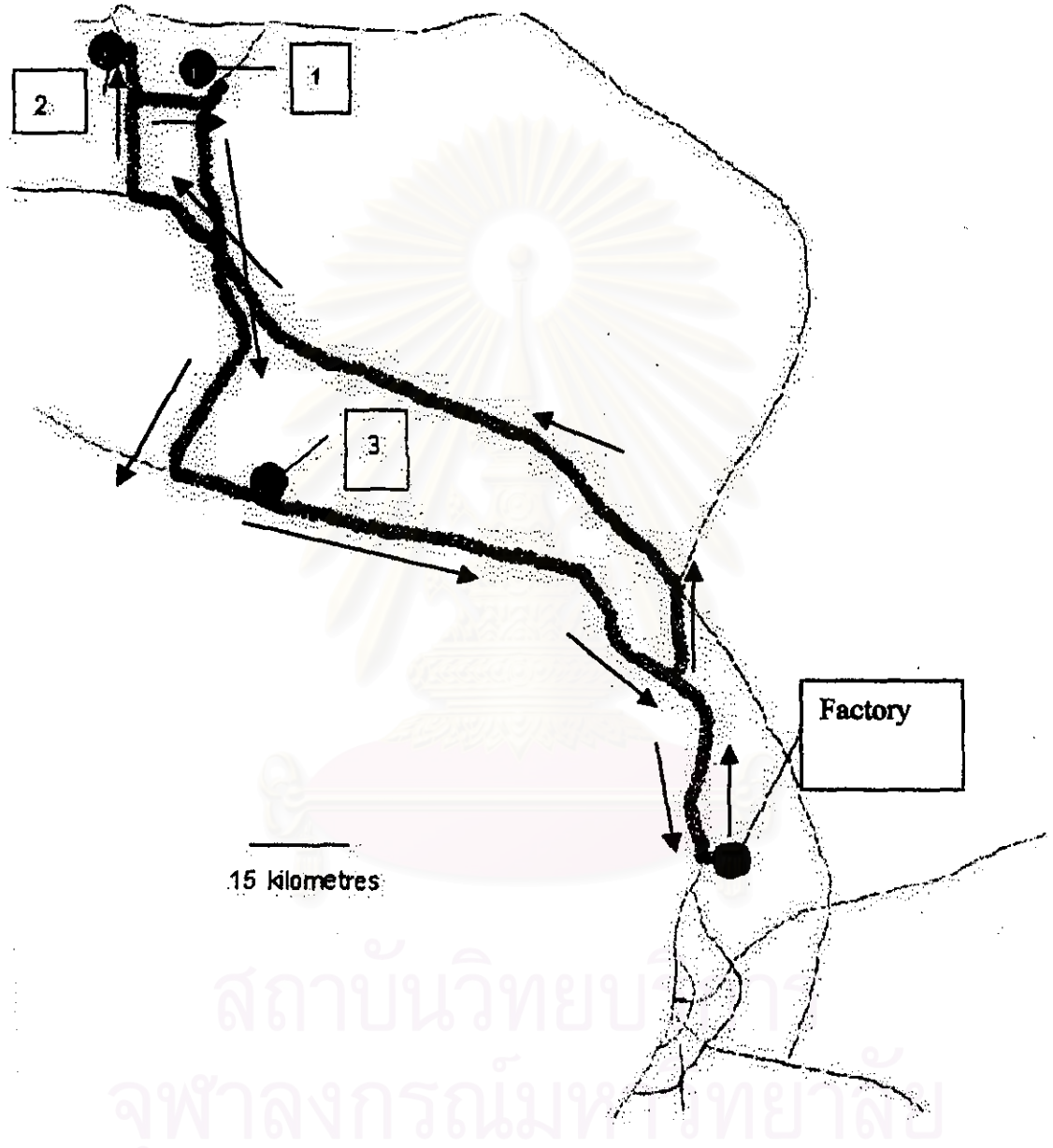

Fig. 6.6 : The optimal route to the customer nos. 1, 2 and 3.

The six wheels Mitsubishi truck is used to deliver the finished products to customer nos. 7, 8, 9, 10 and 11 as shown in Fig. 6.7.

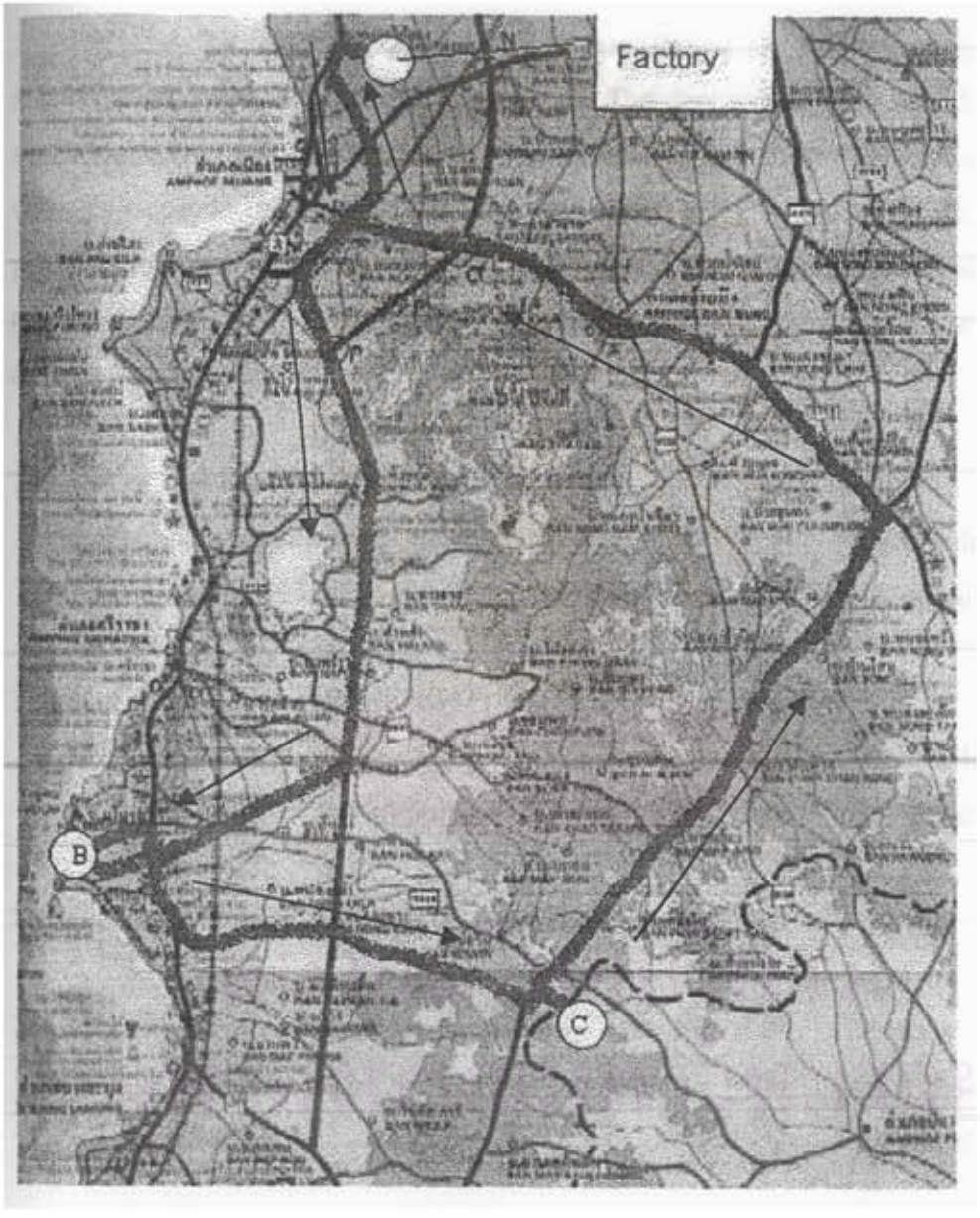

Fig. 6.7 : The route to customer nos. 7, 8, 9, 10 and 11.

This optimal schedule can reduce the small truck tours to customer nos. 10 and 11. For the two small trucks which are not used in delivery to customer nos. 2, 10 and

11, they are used to deliver finished products to customer nos. 4 and 5 only. The routes to these customers are the same as existing route.

6.3.2 Cost Reduction Analysis

The costs associated with transportation are fuel consumption, vehicle maintenance, and subcontracted renting cost. The depreciation cost and driver cost are not calculated in this thesis because they are indirect cost. The depreciation cost of the vehicles depends on time. In this company, there are four trucks to deliver finished products to customers. They can be grouped based on their sizes which are six wheels truck and small trucks. The information is from personal communication with the driver and the data from the accounting department.

The cost of fuel for a six wheels truck is :

Fuel consumption	=	6.5 kilometres/litre
The cost of fuel per kilometre (11.02 baht/litre)	=	1.70 baht/kilometre

The cost of fuel for a small truck is :

Fuel consumption	=	12 kilometres/litre
The cost of fuel per kilometre (11.02 baht/litre)	=	0.92 baht/kilometre

The average maintenance cost is 0.5 baht/kilometre.

Therefore, the direct cost of transportation is

A six wheels truck	=	2.2 baht/kilometre
A small truck	=	1.42 baht/kilometre

After the direct cost is calculated, the total cost of each schedule is determined for one week time. The cost reduction is calculated for each schedule.

- **Existing Schedule**

For the six wheels Isuzu truck,

Serve customer nos. 1 and 3 everyday

Transportation cost per day = transportation cost x tour distance
= 2.2 (baht/km) x 144 (km)
= 316.8 baht

Serve customer no. 6

Transportation cost per day = transportation cost x tour distance
= 2.2 (baht/km) x 10 (km)
= 22 baht

For the six wheels Mitsubishi truck,

Serve customer nos. 7, 8 and 9 everyday

Transportation cost per day = transportation cost x tour distance
= 2.2 (baht/km) x 96 (km)
= 211.2 baht

The total transportation cost for both six wheels trucks per day
= (316.8+22+211.2)
= 549.9 baht

For the two small trucks, their schedules depend on the customer nos. 2 and 4 because both customers require the finished products once a week and 3 times per week respectively. Therefore, the probability for each case is calculated.

For customer no. 2, the probability to deliver to this customer is once a week. The company operates six days per week.
Therefore, the probability to deliver to this customer = 1/6

For customer no. 4, the probability to deliver to this customer is three times per week. The company operates six days per week.
Therefore, the probability to deliver to this customer = 3/6
= 1/2

Table 6.7 : The probability of delivery to customer nos. 2 and 4.

Case	Customer no. 2	Customer no. 4	Probability
1	Yes (1/6)	No (1/2)	1/12
2	No (5/6)	Yes (1/2)	5/12
3	Yes (1/6)	Yes (1/2)	1/12
4	No (5/6)	No (1/2)	5/12

Case 1: the small ISUZU truck delivers finished products to the customer nos. 2 and 5. The small TOYOTA truck serves customer nos. 10 and 11.

- Small Isuzu truck,

Serve customer no. 2

Transportation cost = transportation cost x tour distance
= 1.42 x 168
= 238.56 baht

Serve customer no. 5

Transportation cost = transportation cost x tour distance
= 1.42 x 4
= 5.68 baht

- Small Toyota truck,

Serve customer nos. 10 and 11

Transportation cost = transportation cost x tour distance
= 1.42 x 136
= 193.12 baht

∴Total cost in case 1 = 238.56+5.68+193.12
= 437.36 baht

Case 2: the small ISUZU truck serves customers nos. 10, 11 and 5 while the small TOYOTA truck serves the customer no. 4.

- Small Isuzu truck,

Serve customer nos. 10 and 11

Transportation cost = transportation cost x tour distance

= 1.42 x 136

= 193.12 baht

Serve customer no. 5

Transportation cost = transportation cost x tour distance

= 1.42 x 4

= 5.68 baht

- Small Toyota truck,

Serve customer no. 4

Transportation cost = transportation cost x tour distance

= 1.42 x 302

= 428.84 baht

∴Total cost in case 2 = 193.12+5.68+428.84

= 627.64 baht

Case 3: the small ISUZU truck delivers finished products to the customer no. 2 and then deliver to the customer no. 5. The small TOYOTA truck serves the customer no. 4. For customer nos. 10 and 11, the company has to use a subcontracted truck.

- Small Isuzu truck,

Serve customer no. 2

Transportation cost = transportation cost x tour distance

= 1.42 x 168

= 238.56 baht

Serve customer no. 5

Transportation cost = transportation cost x tour distance

= 1.42 x 4

= 5.68 baht

For small Toyota truck,

Serve customer no. 4

Transportation cost = transportation cost x tour distance

= 1.42 x 302

= 428.84 baht

Subcontracted truck to customer nos. 10 and 11 = 700 baht

∴Total cost in case 3 = 238.56+5.68+428.84+700

= 1373.08 baht

Case 4: the small ISUZU truck delivers finished products to the customer no. 5 and customers nos. 10 and 11.

- Small Isuzu truck,

Serve customer no. 5

Transportation cost = transportation cost x tour distance

= 1.42 x 4

= 5.68 baht

Serve customer nos. 10 and 11

Transportation cost = transportation cost x tour distance

= 1.42 x 136

= 193.12 baht

∴Total cost in case 4 = 5.68+193.12

= 198.8 baht

Therefore, the cost of transportation in one week for the small trucks is summarised in Table 6.8.

Table 6.8 : The existing transportation cost for the two small trucks in one week.

Case	Probability	Cost per day	Expected cost
1	1/12	437.36	36.45
2	5/12	627.64	261.52
3	1/12	1373.08	114.42
4	5/12	198.8	82.83

Total cost for small trucks per day = 36.45+261.52+114.42+82.83

= 495.22 baht

∴Total cost per day = 549.9 + 495.22

= 1045.12 baht

Total cost per week = 1045.12 x 6

= **6270.72** baht

- **Proposed Schedule**

For the six wheels Isuzu truck,

Serve customer nos. 1 and 3 everyday

Transportation cost per day = transportation cost x tour distance

= 2.2 x 122

= 268.4 baht

Motorway fee = 50 baht

Driver can have lunch at the company = -30 baht

Total = 288.4 baht

Serve customer no. 6

Transportation cost per day = transportation cost x tour distance

= 2.2 x 10

= 22 baht

For the six wheels Mitsubishi truck,

Serve customer nos. 7, 8 and 9 everyday

Transportation cost per day = transportation cost x tour distance

= 2.2 x 96

= 211.2 baht

∴The total transportation cost for both six wheels trucks per day

= (288.4+22+211.2)

= 521.6 baht

For the two small trucks, their schedules also depend on customer nos. 2 and 4 because both customers require the finished products once a week and 3 times per week respectively. Therefore, the cost for each case and the expected cost are calculated.

Case 1: the small ISUZU truck delivers finished products to the customer no. 2 via the Motorway and then serves customer no. 5. The small TOYOTA truck serves customers nos. 10 and 11.

- Small Isuzu truck,

Serve customer no. 2

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 105
	=	149.1 baht
Motorway fee	=	60 baht
Driver can have lunch at the company	=	-30 baht
Total	=	179.1 baht

Serve customer no. 5

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 4
	=	5.68 baht

- Small Toyota truck,

Serve customer nos. 10 and 11

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 108
	=	153.36 baht

∴Total cost in case 1	=	179.1+5.68+153.36
	=	338.14 baht

Case 2: the small ISUZU truck serves customers nos. 10, 11 and 5 while the small TOYOTA truck serves the customer no. 4.

For the small Isuzu truck,

Serve customer nos. 10 and 11

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 108
	=	153.36 baht

Serve customer no. 5

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 4
	=	5.68 baht

For the small Toyota truck,

Serve customer no. 4

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 302
	=	428.84 baht

∴Total cost in case 2	=	153.36+5.68+428.84
	=	587.88 baht

Case 3: the small ISUZU truck delivers finished products to the customer no. 2 via the Motorway in the morning and then serves customers nos. 10 and 11 in the afternoon. The small TOYOTA truck serves the customer no. 4. For the customer no. 5, the company has to use a subcontracted truck.

For the small Isuzu truck,

Serve customer no. 2

Transportation cost	=	transportation cost x tour distance
	=	1.42 x 105
	=	149.1 baht
Motorway fee	=	60 baht
Driver can have lunch at the company	=	-30 baht
Total	=	179.1 baht

Serve customer nos. 10 and 11

Transportation cost = transportation cost x tour distance
= 1.42 x 108
= 153.36 baht

For the small Toyota truck,
Serve customer no. 4

Transportation cost = transportation cost x tour distance
= 1.42 x 302
= 428.84 baht

Subcontracted truck to customer nos. 10 and 11 = 100 baht

Total cost in case 3 = 179.1+153.36+428.84+100
= 861.3 baht

Case 4: the small ISUZU truck delivers finished products to the customer no. 5 and customers nos. 10 and 11.

For the small Isuzu truck,
Serve customer no. 5

Transportation cost = transportation cost x tour distance
= 1.42 x 4
= 5.68 baht

Serve customer nos. 10 and 11

Transportation cost = transportation cost x tour distance
= 1.42 x 108
= 153.36 baht

∴Total cost in case 4 = 5.68+153.36
= 159.04 baht

The cost of transportation in one week time for the two small trucks is summarised in Table 6.9.

Table 6.9 : The proposed transportation cost for two small trucks in one week.

Case	Probability	Cost per day	Expected cost
1	1/12	338.14	28.18
2	5/12	587.88	244.95
3	1/12	861.3	71.78
4	5/12	159.04	66.27

Total cost for the two small trucks per day = 28.18+244.95+71.78+66.27

= 411.17 baht

∴ The total cost of transportation per day = 521.6+411.17

= 932.77 baht

Total cost per week = 932.77 x 6

= **5596.62** baht

- **Optimal Schedule**

For , it is used to deliver finished products to customer nos. 1, 2, 3 and 6. Customer no. 2 requires the finished products once a week. There are two possibilities for the delivery tours.

The first case, when the customer no. 2 requires the finished products, the truck goes to customer nos. 2, 1 and 3 respectively.

Serve customer nos. 2, 1 and 3 once a week

Transportation cost per tour = transportation cost x tour distance

= 2.2 x 137

= 301.4 baht

Motorway fee = 50 baht

Total = 351.4 baht

The second case, the six wheels Isuzu truck serves customer nos. 1 and 3 five times a week

Transportation cost per day = transportation cost x tour distance
= 2.2 x 122
= 268.4 baht
Motorway fee = 50 baht
Driver can have lunch at the company = -30 baht
Total = 288.4 baht per day
Transportation cost per week = 288.4 x 5
= 1442 baht

Serve customer no. 6

Transportation cost per day = transportation cost x tour distance
= 2.2 x 10
= 22 baht
Transportation cost per week = 22 x 6
= 132 baht

Therefore, the transportation cost for the six wheels Isuzu truck per week
= 351.4+1442+132
= 1925.4 baht

For the six wheels Mitsubishi truck,

Serve customer nos. 7, 8, 9, 10 and 11 everyday

Transportation cost per day = transportation cost x tour distance
= 2.2 x 139
= 305.8 baht
Transportation cost per week = 305.8 x 6
= 1834.8 baht

For the two small trucks, they are used to deliver finished products to customer no. 4 three times per week and customer no. 5 everyday.

- Small Toyota truck,

Serve customer no. 4 three times per week

Transportation cost per times = transportation cost x tour distance

= 1.42 x 302

= 428.84 baht

Transportation cost per week = 428.84 x 3

= 1286.52 baht

- Small Isuzu truck,

Serve customer no. 5 everyday

Transportation cost per day = transportation cost x tour distance

= 1.42 x 4

= 5.68 baht

Transportation cost per week = 5.68 x 6

= 34.08 baht

∴Total cost per week = 1925.4+1834.8+1286.52+34.08

= **5080.8** baht

6.3.3 Comparison of Cost

Table 6.10 shows the comparison of cost of transportation in each schedule.

Table 6.10 : Comparison of transportation cost in each schedule.

Schedule	Existing Schedule	Proposed Schedule	Optimal Schedule
Cost per week (baht)	6,270.72	5,596.62	5,080.8
Cost per year (baht)	**326,077.44**	**291,024.24**	**264,201.6**

Therefore, the proposed schedule can save up to 35,000 baht per year or 10.75 % from the existing schedule. In addition, if the company can increase the capacity of the six wheels trucks, the optimal schedule can then be achieved. The optimal schedule can save up to 62,000 baht per year or 18.98 % from the existing schedule.

6.3.4 Advantages

- The proposed schedule can reduce the cost of transportation up to 35,053.2 baht per year or 10.75 % from the existing schedule. This is only calculated from the direct cost. There are some other indirect costs for example, the driver cost, depreciation cost and the opportunity cost.

- When the trucks travel via the Motorway, the drivers have spare time to maintain their trucks or the drivers may help the warehouse workers to load the finished products. In addition, the speed throughout the journey is rather constant therefore, the fuel consumption is optimised.

- The company has better delivery capacity. The trucks may deliver the finished products via the Motorway more than two times per day.

- This study can be applied to other companies to improve the transportation operations.

6.3.5 Disadvantages

- The drivers may have to work harder in some days. They may not accept this new schedule.

- While travelling via the motorway, the driver may not be alert and careful which might cause an accident from driving over a speed limit. The fuel consumption is then excessive.

6.4 Strengths and Weaknesses Analyses

The strength and weakness analysis has been conducted to evaluate the proposed warehouse layout and the proposed delivery schedule.

6.4.1 Proposed Warehouse Layout

Strengths

- The travel distance in materials handling is reduced comparing with the existing warehouse layout.

- As the time in items picking is reduced, the overall capacity is improved. The waiting time is then reduced and hence the chance of interruption in the production line is minimised.
- All items are located in the place sorted by model i.e. parts for the same model are located together which is similar to the existing location. However, the frequency of use has been determined in the proposed system especially items ordered by the machining department. Most of these items are moved from rack nos. 11 and 12 in the existing layout to rack nos. 7 and 8 in the proposed system which are closer to the dock.
- The proposed layout is still of the same height. Hence, the workers are familiar with the location that they would not feel unacceptable.
- Data in storing items are systematically categorised therefore, the picking tour can be optimally planned. The workers then plan the route prior to picking.

Weaknesses

- All items are located in the specific place as in the existing warehouse. As a result, this warehouse system is rather inflexible.
- Some imported items have their constraint such as the size of the pallet. If the amount of that specific items are excessive, a spare location is then used which makes the picking tour more complicated.
- The workers may protest the change in the beginning.
- The warehouse workers have to move all items from the existing locations to the new locations, which may affect the production line.

6.4.2 Proposed Delivery Schedule

Strengths

- The travel distance of the delivery trucks is reduced in some routes.
- The delivery time is reduced because the travel distance is shortened and the road surface is of better quality. When the driver travels at a constant speed, the fuel consumption can be optimised.
- The delivery trips in each day can be increased as from the time saving in each trip.

- The data in delivery are systematically justified based on the restrictions of each customer and the customers' locations. As a result, the optimum efficiency can be met.
- The trend of petrol cost increases therefore, the proposed schedule and routes can save even more in the future.
- The cost from the subcontractor is reduced because the proposed schedule only hire a subcontractor for a necessary case and nearby costomers.

Weaknesses

- In reality, there might be some changes from unexpected sources such as a crash on the motorway which causes a traffic congestion. Therefore, the fixed schedule may not be optimal.
- The drivers may protest the change as they have to work more efficiently.
- The proposed route to customer nos. 7, 8 and 9 may not be appropriate as there are some security checkpoints which might be time consuming.

6.5 Summary

In this Chapter, the evaluation processes have been carried out in the materials handling routing operations in the warehouse and transportation operations. For the materials handling routing, the proposed warehouse layout can save 12,350 metres or 46.55% from the existing warehouse layout in November 1999. For the transportation operation, the new schedules have been proposed to the company. They are called the proposed schedule and the optimal schedule. The proposed schedule can save up to 35,000 baht per year or 10.75 % from the existing schedule while the optimal schedule can save up to 62,000 baht per year or 19 % from the existing schedule.

Finally, the strength and weakness analysis has been summarised for the proposed warehouse layout and the proposed delivery schedule.